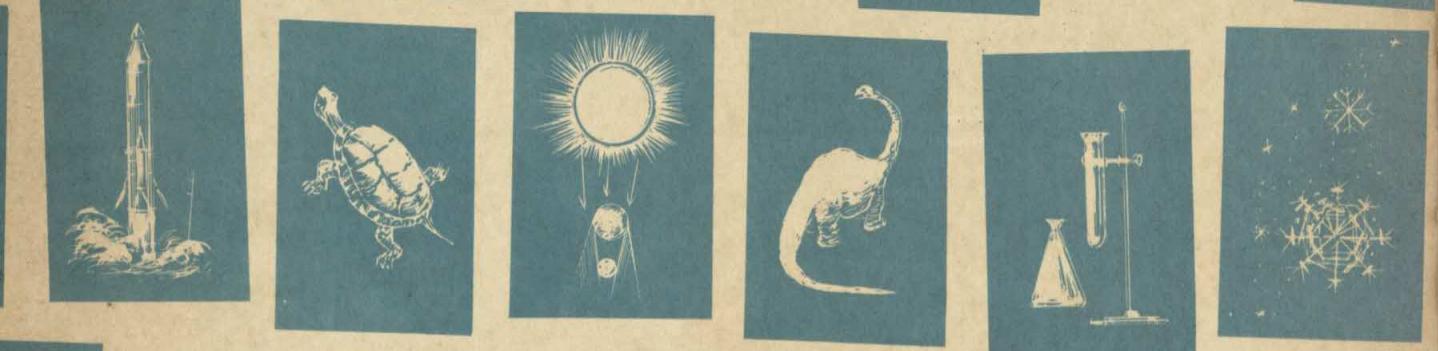
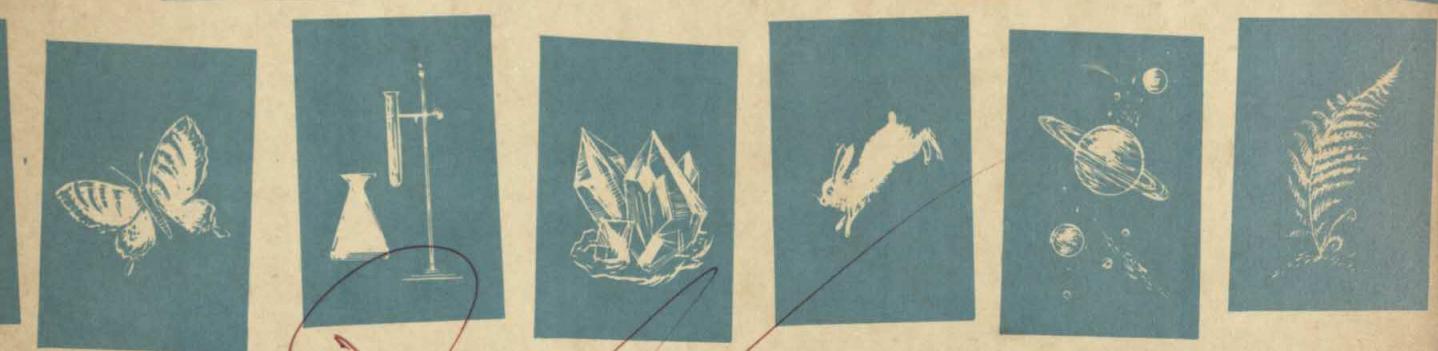


The
**HOW
AND
WHY**
Wonder Book of

THE MOON

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THE MOON

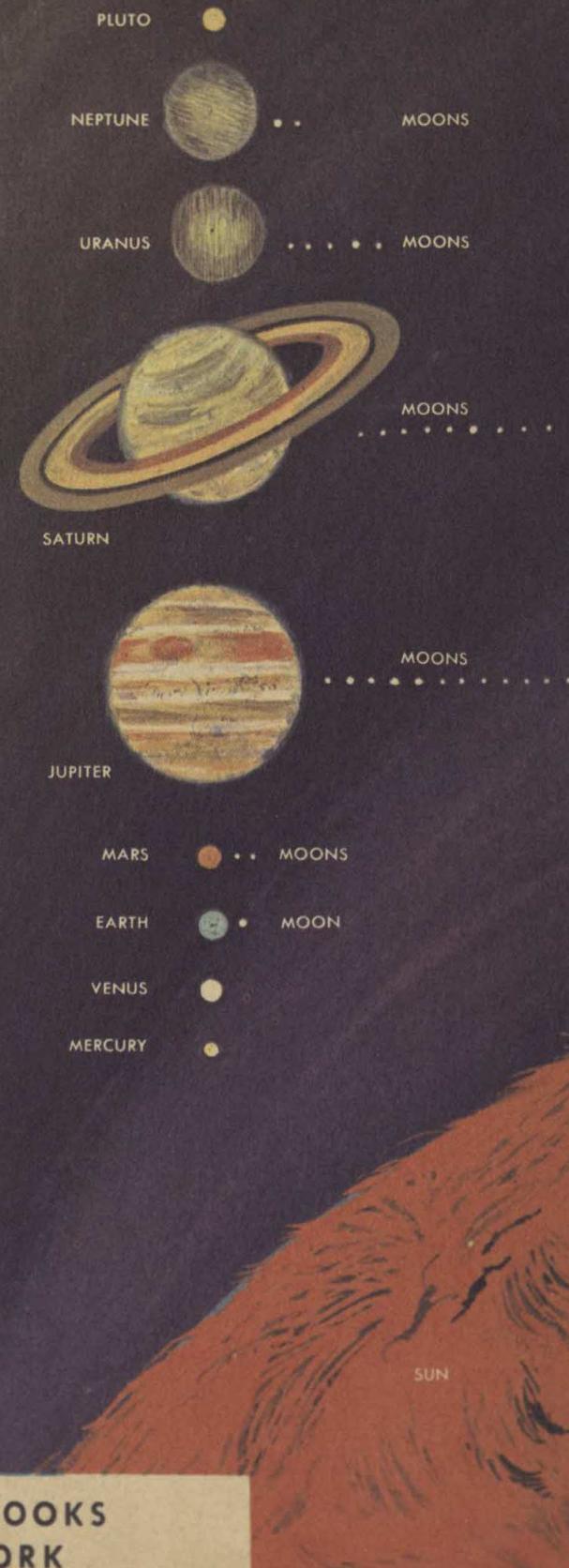
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WONDER BOOKS
NEW YORK



Introduction

The moon has been the subject of speculation and imaginative questioning by mankind through the ages. A close neighbor in space, its rhythmic sequences of color and form are visible even to the least observing. Yet at times everyone observes the moon. Such a glorious neighbor in space must have a special significance! The wonder of it has raised hundreds of questions. And now the answers may be ours. For at long last man is on the threshold of going to the moon.

This *How and Why Wonder Book of the Moon* prepares the reader to understand the moon explorations. Not only does it summarize much that is already known, it also states clearly some of the major questions yet to be answered. In many ways our attempt to reach the moon illustrates science and technology working hand-in-hand in spectacular ways. At first it seems that only outer space is the laboratory in this exploration. But closer thought reminds us that the results of research of many kinds — from test tubes to mathematics to telescopic probing of the vast universe — have contributed to the soon-to-be accomplished flights to the moon.

Living in the twentieth century is exciting. Think of the opportunities that children at school and whole families at home have to learn about new scientific advances. This *How and Why Wonder Book of the Moon* takes us to the frontiers of knowledge about our Earth's major satellite. Surely moon-gazing, always a popular activity, will never be the same again. And in a day when the question is not "Shall we look at the moon?" but "Shall we take a trip to the moon?", the great yellow sphere emerging in full splendor over the eastern horizon has a new meaning for everyone.

Paul E. Blackwood

12-9-05
11912

Dr. Blackwood is a professional employee in the U. S. Office of Education. This book was edited by him in his private capacity and no official support or endorsement by the Office of Education is intended or should be inferred.

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Published simultaneously in Canada. Printed in the United States of America.



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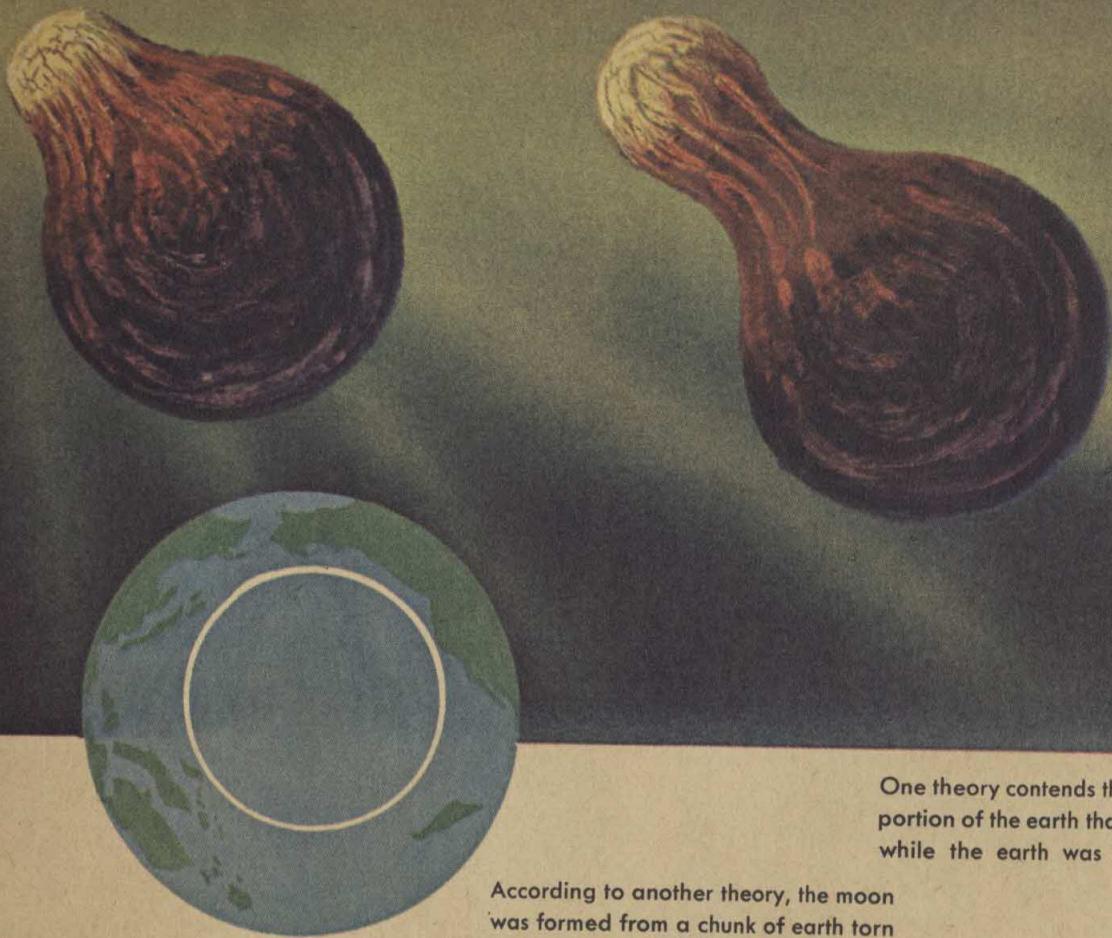
Preface

From the beginning of history, man has been obsessed by the desire to travel to the moon. A seal, carved in Babylon 3,000 years ago, shows a man mounted on the back of a great bird obviously headed for a tiny crescent moon that shows in a corner of the seal.

This is the story of the approaching realization of this age-old dream. Project Apollo is the plan which will one day place a man from earth on the desolation of the moon. What we now know about the moon and what more we must learn about it before we can risk human lives on this exploit are told here. Here also is the story of the carefully detailed preliminary research — the manned and unmanned explorations that must precede the actual event.

This may be man's greatest adventure. It will be one upon which he will embark with his eyes open, not blindly or desperately, as he has on many past explorations. The story of Project Apollo is as exciting as must have been the preliminaries for the voyages of Columbus, about 1490.

James S. Pickering
Hayden Planetarium



According to another theory, the moon was formed from a chunk of earth torn from what is now the Pacific Ocean.

One theory contends that the moon is a portion of the earth that was thrown-off while the earth was still semi-liquid.

Our Neighbor in Space—the Moon

For the first time in all history, man is reaching out to probe the mysteries of space. Scientists have already sent our astronauts more than 150 miles high, hurtling in orbit around the earth at speeds of over 17,000 miles per hour.

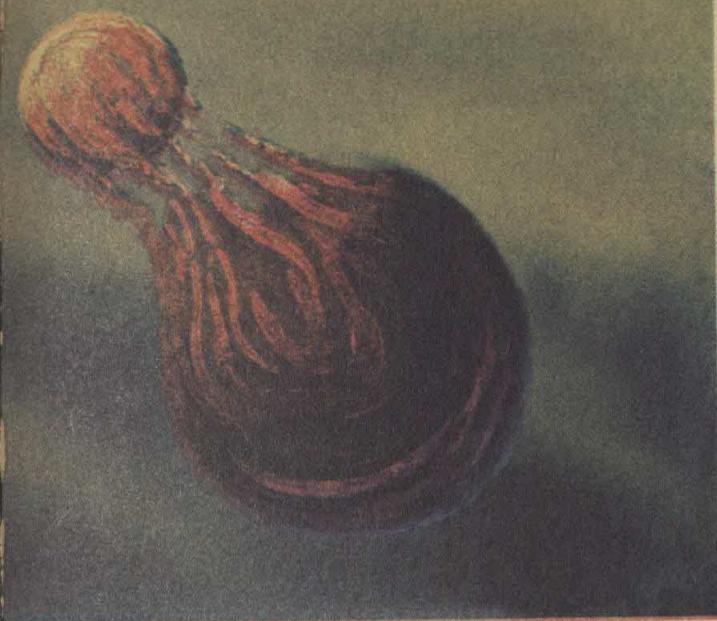
Before you are much older, the first human explorers will set foot on the moon. From there, the next stepping stone in the conquest of space will be Mars, and after that the other planets. Then, at some unforeseeable date in the future, man plans to go on to the distant stars themselves.

Since the moon is the closest of all the heavenly bodies, it will be the first

to be probed by men from earth. In this book, we will seek some answers to questions about what the moon is like; what our astronauts are likely to find when they get there; and how they will make the long and hazardous voyage through the empty reaches of space.

There have been a great many scientific theories about the origin of the moon. Of these, only the three most likely will be discussed here. The first holds that the moon is a thrown-off portion of the earth itself. When the earth was new

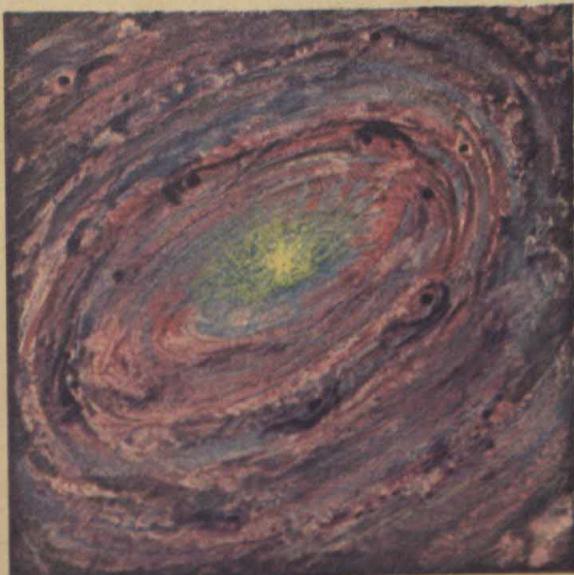
What is the
origin of
the moon?



and in a semi-liquid form, its rapid revolution around the sun caused it to assume the shape of a lop-sided dumbbell. The smaller part of the dumbbell broke away and became the moon.

A corollary to this theory is that after the earth had begun to solidify, a huge chunk of it was torn loose from what is

Most scientists today accept the theory that our solar system was formed from a cosmic cloud.



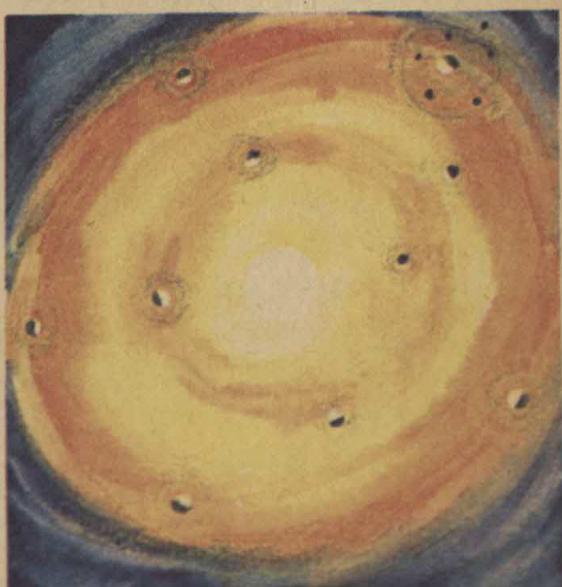
The sun forms.

now the basin of the Pacific Ocean. About the only justification for this latter theory, most scientists think, is the fact that the total mass of the moon would just about fill the hole that is now filled by the Pacific's waters.

Other scientists believe that the moon is actually older than the earth. They contend that the moon is a relic of an earlier stage of the solar system than that during which the earth was formed. Toward the end of the earth's forma-



The planets and moons form within the dust rings.



Moons are captured by the planets' gravitational pull.

tion, it caught the moon in the force of its gravity and captured the moon as a permanent satellite.

Most scientists today, however, accept the theory that the moon and the earth were formed at the same time and of the same basic materials. They think that several billion years ago our solar system was nothing but a cloud of cold dust particles whirling aimlessly through the nothingness of deep space. Then, in response to the laws of gravity, these particles gradually came together to form a huge, spinning disk. As it spun, the disk separated into rings. The nucleus of the disk became the sun, and the particles in the outer rings became the planets. When both earth and moon had been formed, the moon, being much the smaller, was captured by the stronger gravity of the earth and so began to orbit about it just as the earth orbits around the sun. (See ill. p. 5.)

Because the moon is the nearest

**Myths about
the moon**

only body to the earth, and because it appears at different times of the

month in several varied forms, a great many myths and superstitions have grown up about it. Here are a few of the most common.

Many people believe that the moon affects the weather. When the moon changes, they say, the weather changes. As a result we get old-time sayings that have been handed down from generation to generation:

“Clear moon, frost soon.”

“Pale moon means rain. Dark moon means winds.”

“When the moon can be seen in the daytime, the days are cool.”

“Frost in the dark of the moon kills buds and blossoms; frost in the light of the moon does not.”

Anyone who stops to think about it soon realizes that the moon cannot possibly change the weather on earth. First, it is an inert body, a quarter million miles away, which transmits no energy except a weak reflection of the sun. In the second place, the moon can be seen over half the earth at the same time, in the tropics as well as the arctic, and obviously every place on earth does not have the same weather.

Many old-timers also believe that the moon affects the growth of seeds and plants.

“Plant beans when the moon is light.”

“Plant potatoes when the moon is dark.”

“Wood keeps better when cut in the new moon.”

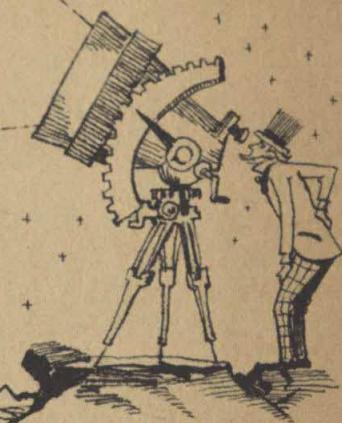
“Trees should only be pruned in the new moon.”

For centuries farmers have planted and tilled their crops in accordance with these ancient rules. But no one has ever been able to prove that the moon has anything at all to do with earthly harvests.

Since long before the first history books were written, people believed that the full moon caused insanity. In fact, the word “lunacy” comes from the Latin word “luna” meaning moon. It was believed that if the full moon shone on a person while he were sleeping, that person would go mad. Another old superstition said that moonlight could cause blindness. But since moonlight is nothing more than reflected sunlight, the sun should cause a great deal more madness and blindness than the moon.



Richard Adams Locke's
"Great Moon Hoax" of 1834.



The moon has always figured prominently in both ancient and modern religion. It was worshipped as a goddess by the Greeks and Romans, as well as native tribes in Asia, Africa, Australia, and North and South America.

Today, the phases of the moon play an important part in the celebration of both Christian and Jewish Holy Days. The Christian festival of Easter always takes place on the first Sunday after the first full moon after the vernal equinox. One of the most sacred of all days in the Jewish faith, Passover, always falls on the first full moon of the spring, from the 14th to the 21st day of the Hebrew month Nizan.

The full moon which is nearest in date to the autumnal equinox (September 23) is known as the "harvest moon." At this time, the moon rises early in the evening for three nights

**What is the
harvest moon?
the hunter's moon?**

in succession, and is entirely or nearly full on each of the nights. Thus the light of the moon lengthens the natural period of twilight, and allows farmers extra hours of working time in which to harvest their crops before the fall frosts set in.

The "hunter's moon" follows the harvest moon, one month later, and is very similar to it. It is so called because the hunting season follows the gathering in of the crops.

There have been many fantastic tales told about the moon.

**What was
the "Great
Moon Hoax"?**

But perhaps the most ridiculous was the "great moon hoax" of 1834. The amazing thing was that most of the people of the world, including a great many leading scientists, were completely taken in by it.

It all began one afternoon when a reporter for the *New York Sun*, Richard Adams Locke, was trying to think of a

sensational story to write for his paper. It had been a dull day for news. Nothing of much importance was happening in the city. So Locke let his imagination take over.

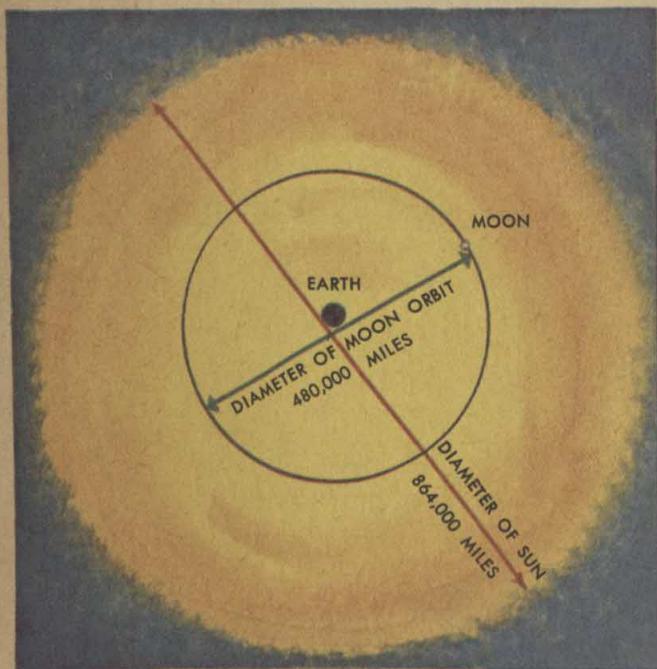
He knew that Sir John Herschel, the famous British astronomer, was making moon observations at that time from the Cape of Good Hope in Africa. That was enough of a start for the imaginative Mr. Locke. His story took it from there.

He reported that Sir John had developed a telescope twenty-four feet in diameter, which was big enough to bring the moon into view at a relative distance of 150 yards. Through it, the astronomer could see flowers, white beaches,

and a huge jewel-like rock, probably a ruby, that was 90 feet high. In a valley nearby, so went Locke's fanciful story, were herds of small bison and blue unicorns, as well as flocks of pelicans and other birds.

As the days went past, Locke's news stories grew even more fantastic. He reported the finding of two-legged beavers, horned bears, and human-like creatures that were half-man and half-bat.

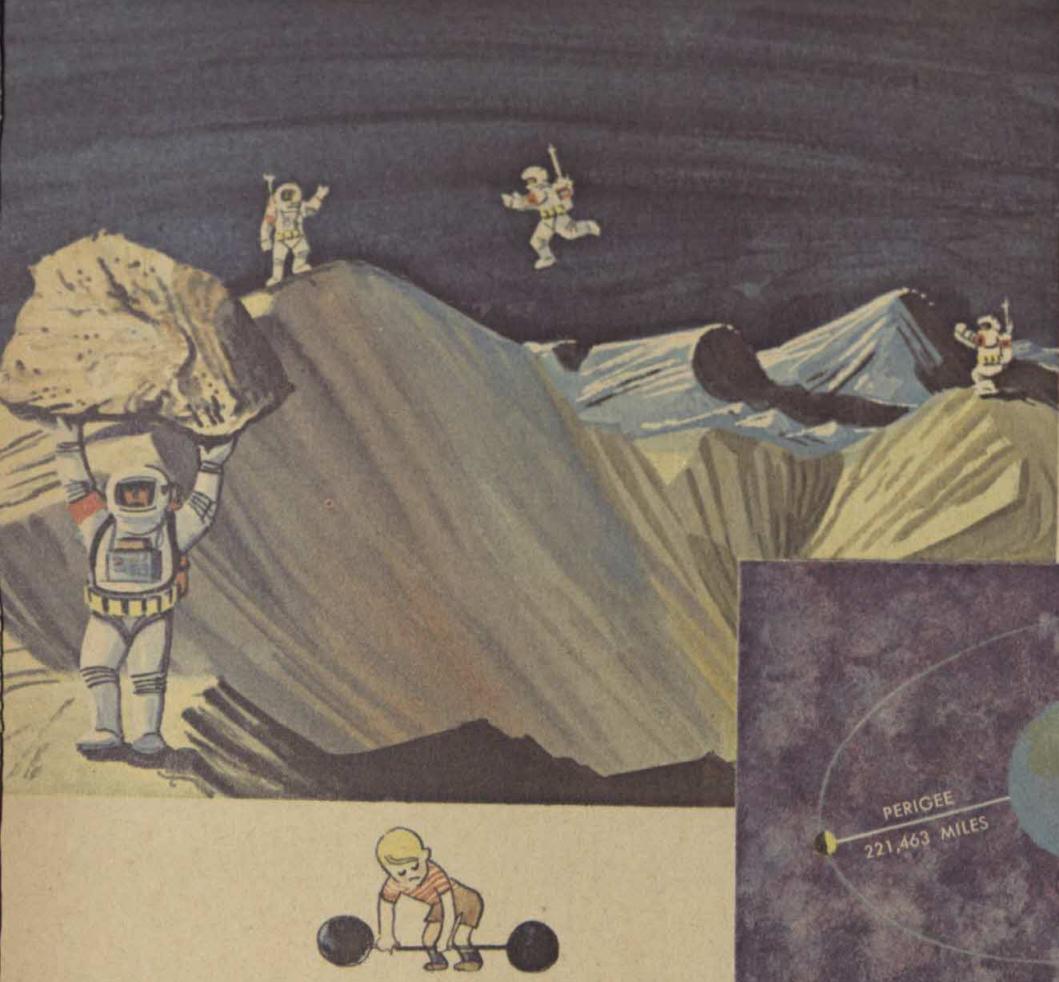
After a few weeks of writing this fabulous hoax, Locke decided to quit. But by this time, the circulation of *The Sun*, which had been a small, unsuccessful paper, had ballooned into the largest in the city. Locke himself became famous, even after he had confessed that his stories were only wild figments of his imagination.



If you wonder about the relation of size between moon and sun, you might understand it better if you realize that the sun is much larger than the earth-moon system together.

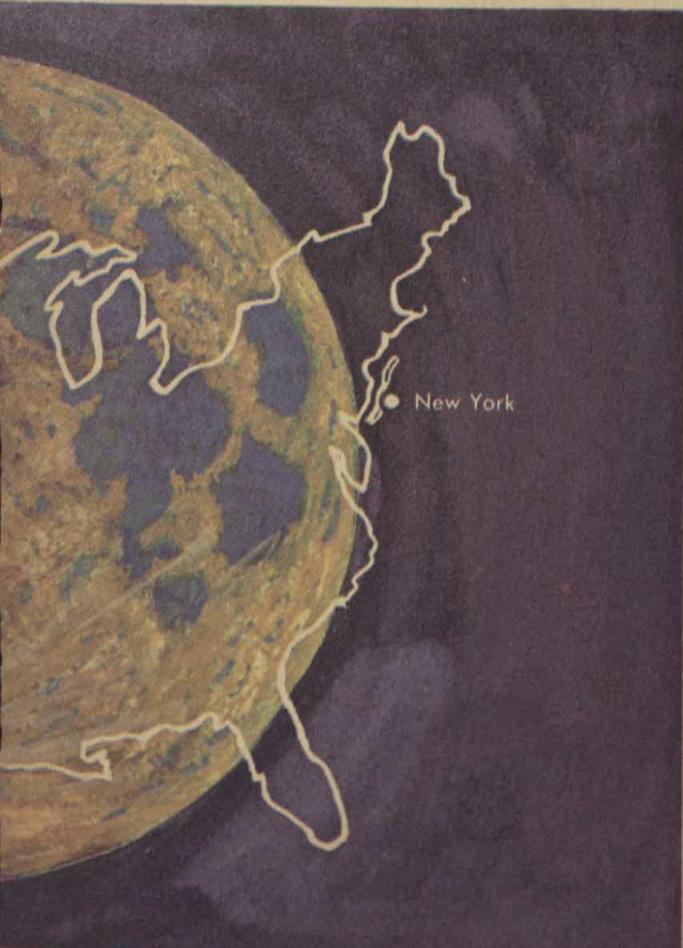
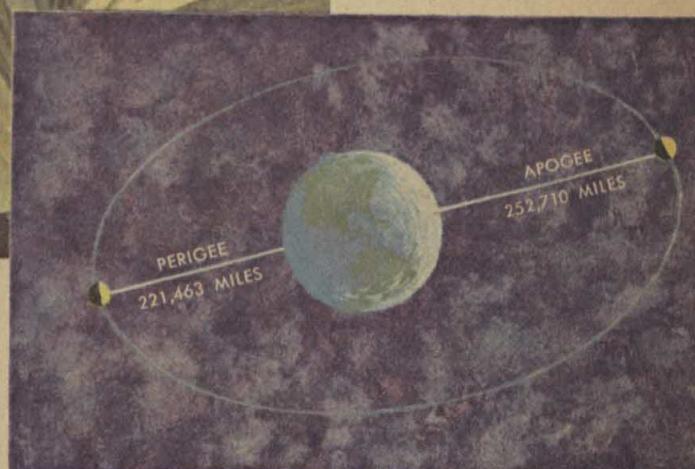
The moon is "only" 6,800 miles in circumference and 2,160 miles in diameter. This means that a line drawn through its axis would extend "only" from New York to Salt Lake City.





Since the moon's gravitational pull is only 1/6 of the earth's, it would be easy to break earthly leaping and weight-lifting records on the moon.

The moon swings around the earth in an elliptical orbit which is 252,710 miles away from the earth at its farthest point, and 221,463 miles at its nearest point.



The moon is 2,160 miles in diameter, roughly one-quarter the diameter of the earth. In relation to the width of the United States, this means that a line drawn through the axis of the moon would extend from New York to Salt Lake City, Utah.

The moon's mass (roughly its weight) is 1/81st that of earth's. Since the gravitational attraction of a body depends upon its mass, scientists have determined that the pull of gravity on the moon's surface is just one-sixth of that on earth. This means that if you normally weigh 150 pounds, your weight on the moon would be only 25 pounds. If you can jump three feet into the air on earth, you could jump 18 feet on the

How large is the moon?

moon. To use another example, if you can lift 100 pounds on earth, you could lift 600 pounds on the moon. Thus, when the first explorers reach the moon, they will have little difficulty in moving and lifting heavy pieces of machinery and equipment that they could not even budge on earth.

The moon swings around the earth in a

**How far away
is the moon?**

slightly elliptical orbit. At its *apogee*, its farthest point from earth, the moon is 252,710 miles from us. At its *perigee*, or closest point, it is 221,463 miles away. The average distance from the earth to the moon is 238,857 miles. A spaceship, launched from earth, would take roughly two and a half days to reach its destination. Light from the moon reaches the earth in about one and one-quarter seconds. Radio and television signals travel at the same speed as light. This means that an explorer on the moon would be able to converse freely, via radio, with his earth base.

The earth rotates on its axis once every

**What are day
and night on
the moon?**

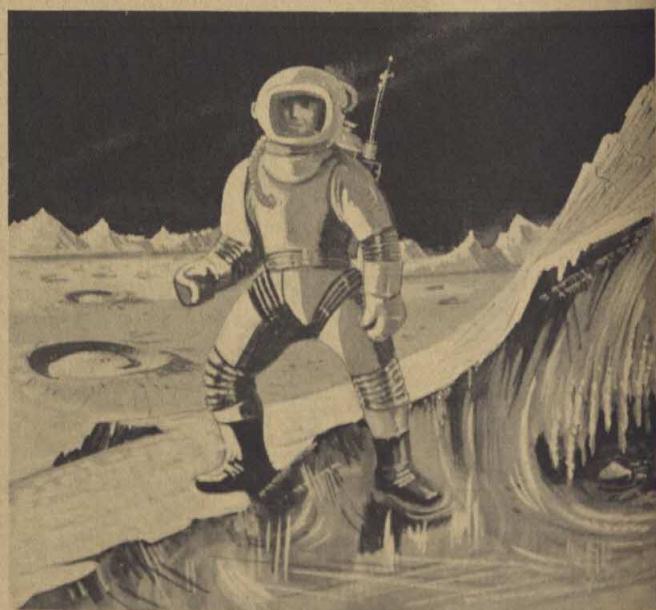
24 hours. Thus, its average day and night are each of 12 hours duration. The moon orbits around the earth once every $27\frac{1}{3}$ days, and in this same period it turns only once on its axis. Thus, the lunar "day" is equal to about 14 earth days, and the lunar "night" is of the same duration.

Of course, one side of the moon is *always* illuminated by the sun — just as is one side of the earth. Thus, when

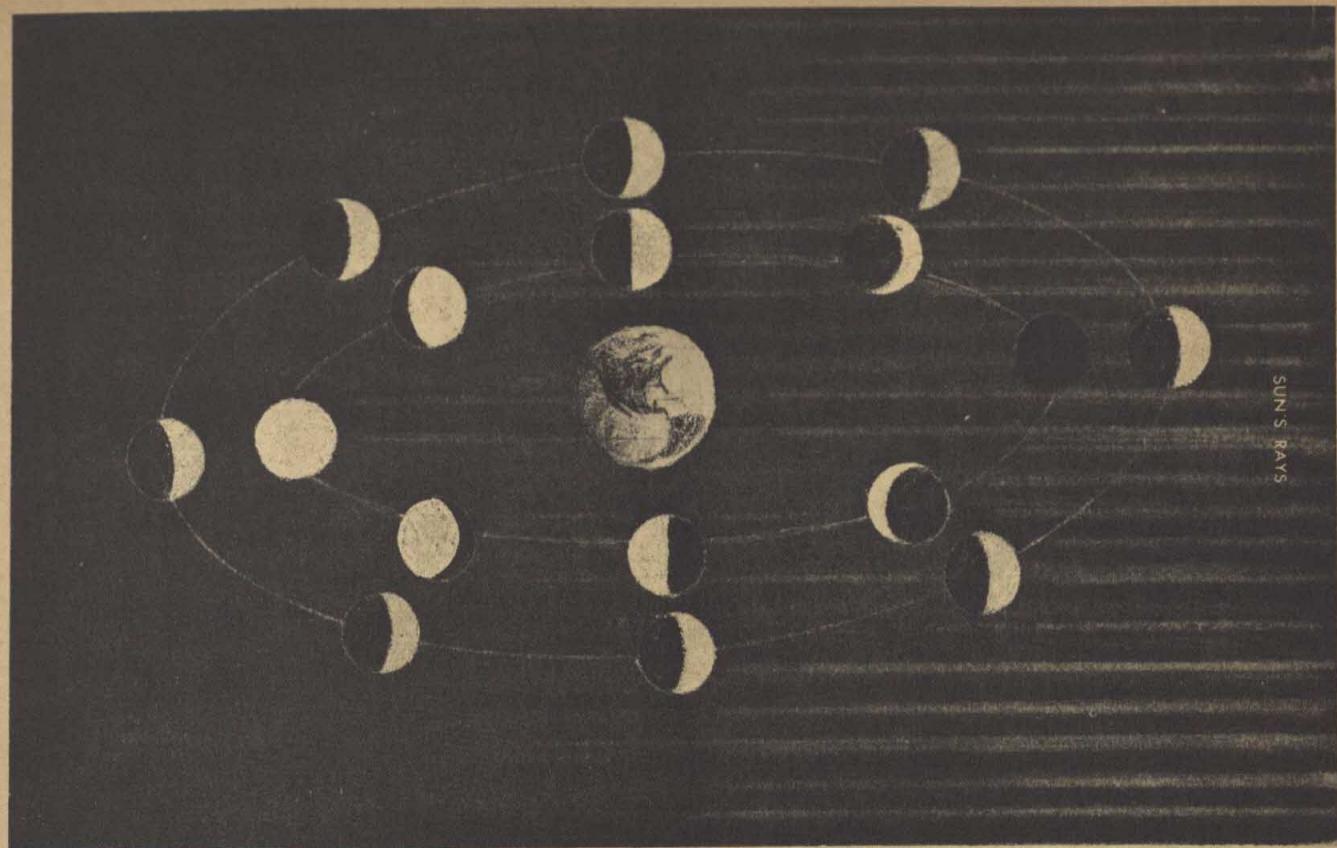
it is "night" in one moon-hemisphere, it is "day" in the other.

During the "day," when the surface of the moon is fully exposed to the sun's rays, the temperature of its surface is about 220 degrees F. This is slightly higher than the boiling point of water. At "night" on the moon, the temperature plunges to about 250° F. below zero.

But since the moon has no atmosphere to absorb and transfer heat, the dark shadow cast by an overhanging rock is as cold during the "day" as it would be at "night." Thus, if you were standing on the moon with your right foot in the full sunlight, and your left foot in deep shadow, then your right foot would be exposed to 220 degree heat and your left foot to 250-below-zero cold. It is easy to see that the first moon explorers are not going to have a very comfortable time.



The air on earth, when exposed to the sun, evens out the temperature between sunny and shaded places. But the lack of atmosphere on the moon makes the sunlit spots "boiling hot" and the shadows "freezing cold," with nothing in between.



If you could look at earth and moon from a point in space, the moon would always appear half dark. The fact that we see the various phases (inner ellipse) is caused by the changing angle under which we see the sunlit surface of the moon from our observation point on earth.

Like the earth, the moon creates no light of its own. The moonlight we see on a clear night is only a reflection of the sunlight. For this reason, the moon seems to assume different shapes at different times of the lunar month as it orbits the earth. These are called the *phases* of the moon.

When, in its journey around the earth, the moon comes into a direct line with the sun, we cannot see it at all. This is called the "new" moon. Twenty-four hours later, a small part of it reflects the sunlight as a thin crescent. This is commonly known as a "sickle" moon. After a week, the crescent enlarges to become a "quarter" moon. And in another week, the entire ball of the moon, or the "full" moon, is ex-

Why does the moon shine?

posed to our view. The moon's phase then gradually recedes into the third quarter, into a crescent again, and finally into the new moon to complete once more its monthly circuit.

If you were an explorer standing on the moon and looking at the earth, you would see the same effects. The earth would shine in the reflected light of the sun, and you could properly call it "earthlight." At various phases of the earth's passage overhead, you would see "full" earth, "quarter" earth, and "crescent" earth. And, of course, at "new" earth, you could not see it at all.

It is quite likely that you would be able to distinguish the earth's varied colors — the green of the forested areas, the brown of the deserts, and the blue-black of the seas.

The color of the moon, as we see it, depends upon its reflected light as it is filtered through the earth's atmosphere. Thus, in wintertime, when the moon rides higher in the sky

What color is the moon?

and its rays shine almost directly down, it appears to be white or silver. In summer, the moon moves at a lower angle across the sky and its rays are filtered through thicker layers of atmosphere. It then appears to be yellow or golden.

If you were standing on the surface of the moon itself, with no atmosphere to reflect or refract the light, the moon's color would probably be deep black in the shadow and gray-white in the direct sunlight.

If you have ever been to the seashore,

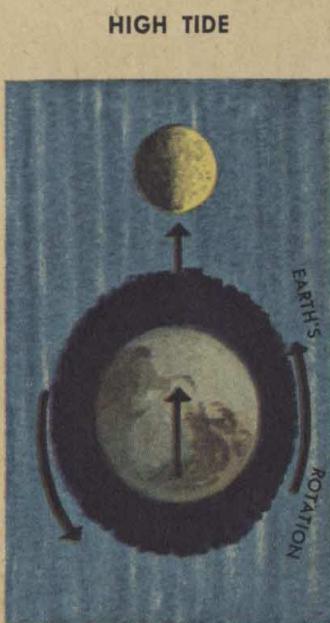
How does the moon cause tides? you must have observed the daily ebb and

flow of the tides. At certain time of the day, the level of the water rises sometimes as much as ten or twenty feet. A few hours later the tide has receded, leaving behind it a long stretch of empty beach. These tidal flows are caused mainly by the gravitational pull of the moon, and to a lesser degree, of the sun.

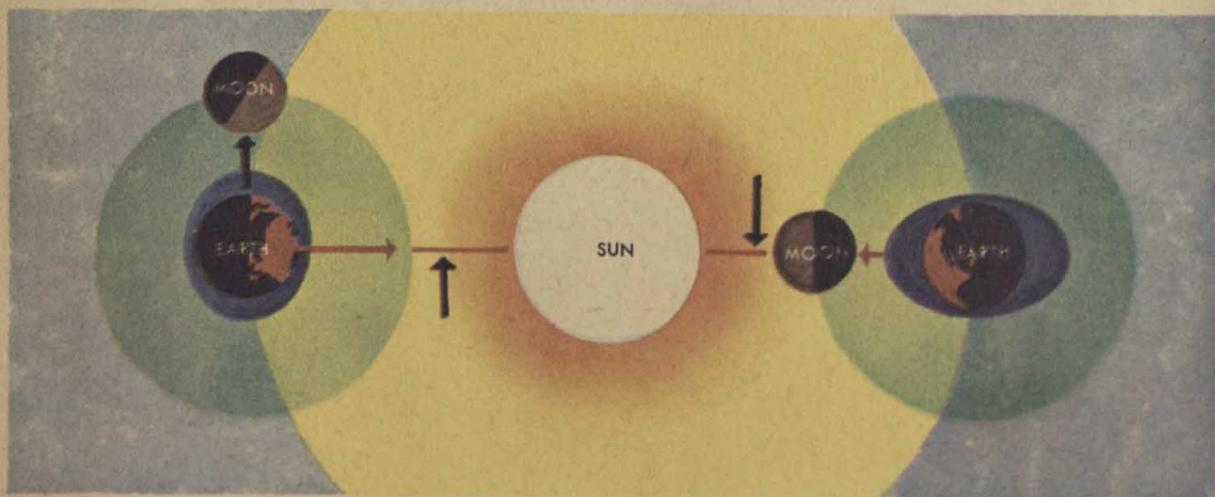
During the periods of new moon and full moon, the earth, the sun, and the



LOW TIDE



There is a high tide and a low tide about every six hours. In other words, during approximately every 24 hours, at any point on the shore, there are two high tides and two low tides.



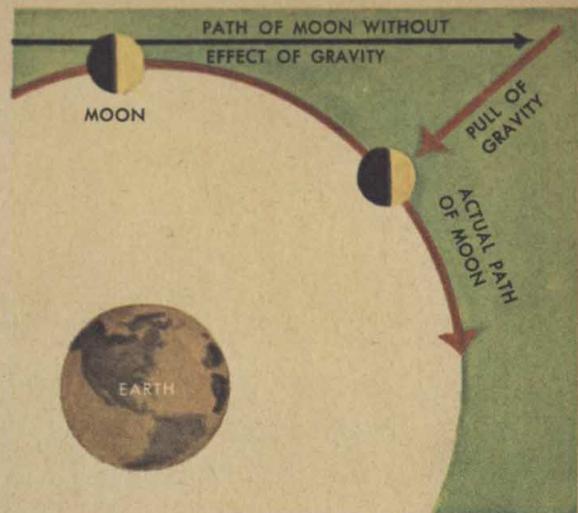
When the moon and the sun line up on the same side of the earth, or when the sun and the moon are in line, but on opposite sides of the earth, the combined gravitational pull creates unusually high or *spring tides*. When sun and moon are at right angles, the gravitational pull of each works against the other and unusually low or *neap tides* result.

moon are in a straight line. Thus, the moon and sun work together to cause extremely high tides, known as "spring" tides. When the moon is in its first and third quarters, it is at right angles to the sun in relation to the earth. At these times, the moon and sun are pulling against each other, resulting in lower tides, called "neap" tides.

As billions of tons of sea water are constantly being dragged back and forth across the ocean floors, the friction they create acts as a brake on the rate of the earth's rotation. And as the earth's rotation slows, the days lengthen. The result is that our days are getting about one second longer every 100,000 years.

If you attach a weight to a string and swing it around your head, the weight travels in a circle. This is because two opposing

Why does the moon stay in orbit?

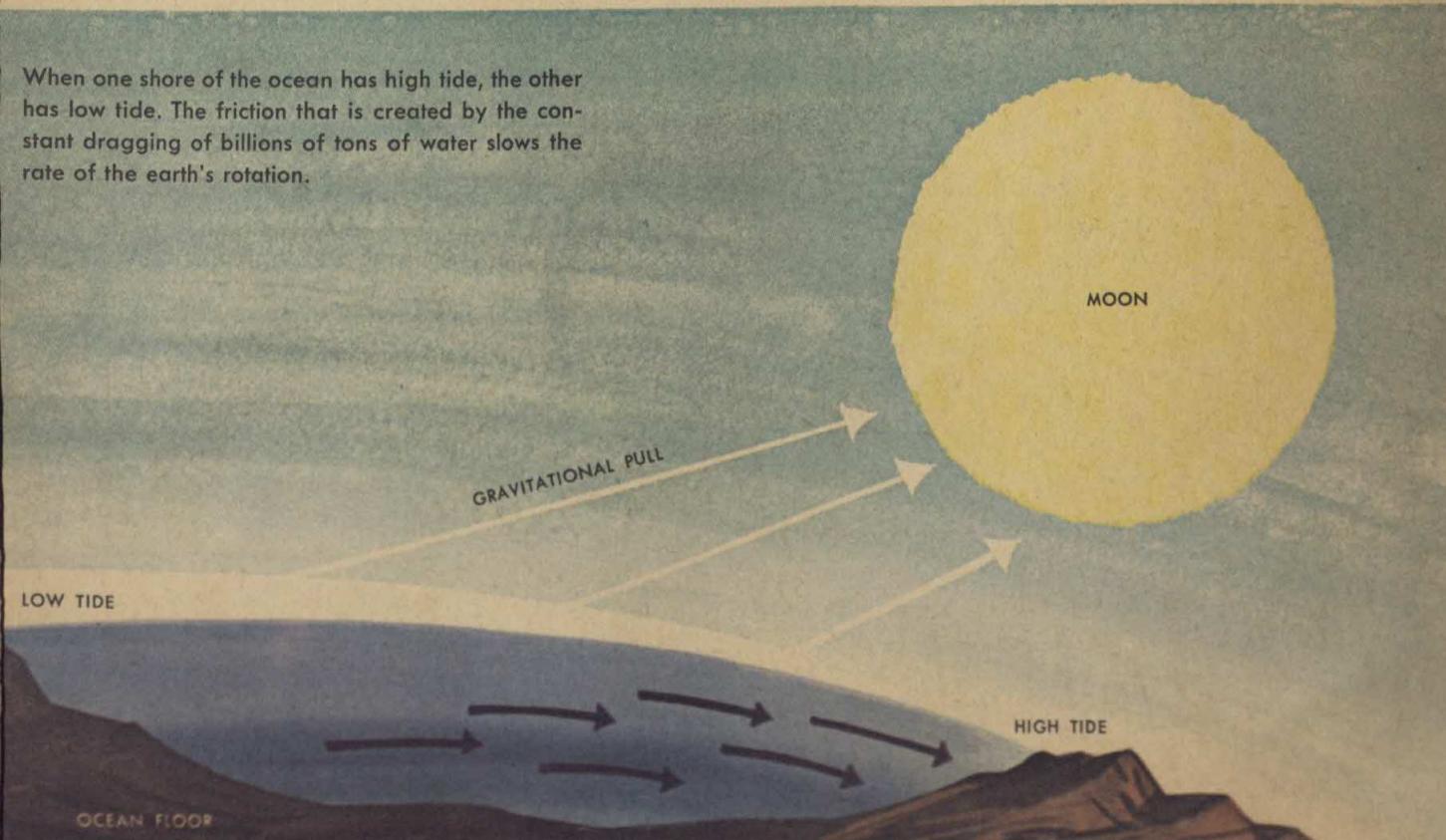


The diagram will help you to understand how and why the moon stays in orbit.

forces are working on it at the same time. A force called *tangential velocity* tends to throw the weight off in a straight line, just as the weight would do if you let go of the string. But the string, held in your hand, keeps pulling it back. Thus the weight moves in a circle.

The moon revolves in a circle around the earth in response to similar forces.

When one shore of the ocean has high tide, the other has low tide. The friction that is created by the constant dragging of billions of tons of water slows the rate of the earth's rotation.



The orbit of the moon becomes proportionally larger with the slowing down of the earth's rotation.

Hurtling along at a speed of 2,287 miles per hour, *tangential velocity* tries to fling the moon off in a straight line away from the earth. But the earth's gravity acts in the same way as the string; it keeps pulling the moon back towards the earth. Thus the moon travels serenely around us in its orbit.

It is this same principle that allows the spaceships of our astronauts to stay in an earth orbit. The outward thrust of the ship is equalized by the downward pull of the earth's gravitational force, and so the spaceship keeps going around in a circle. When the astronaut wishes to bring his vehicle back to earth, he fires a retrorocket which slows the ship's orbital speed and thus upsets this delicate relationship; then the ship falls back into the earth's atmosphere.

We have seen that the friction of the

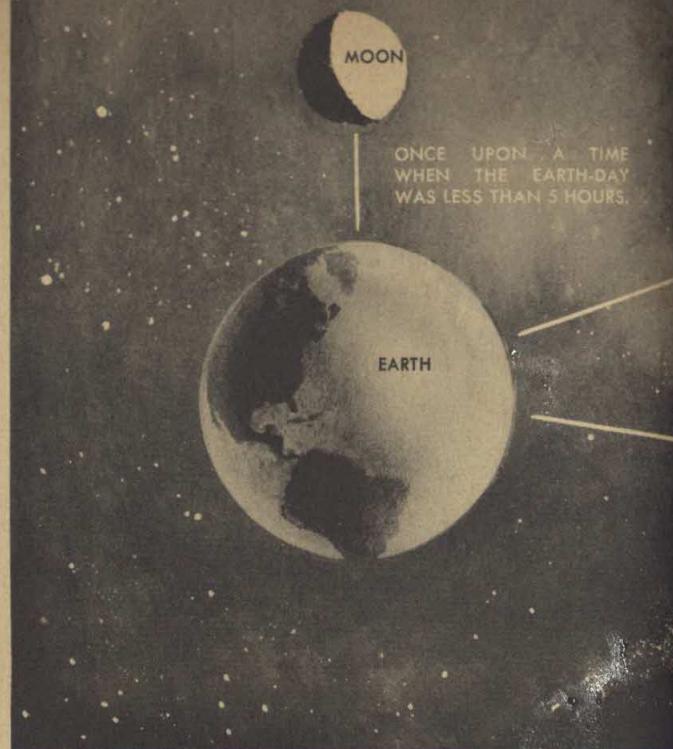
**Will the moon
always stay
in orbit?**

tides has a braking effect upon the earth's rotation, and

that as a result our

days are becoming longer, at the rate of about 1/1,000th of a second a century. This rate of change is so infinitesimal that it seems absurd even to think about it. But, over future eons, it will affect the ultimate destiny of the moon, and will eventually (after countless billions of years) probably be the cause of the moon's break-up, disintegration, and death.

This tidal friction was just as effective on the earth and on the moon when both bodies were in a liquid, or semi-plastic, stage, as it is today on the waters



ONCE UPON A TIME
WHEN THE EARTH-DAY
WAS LESS THAN 5 HOURS.

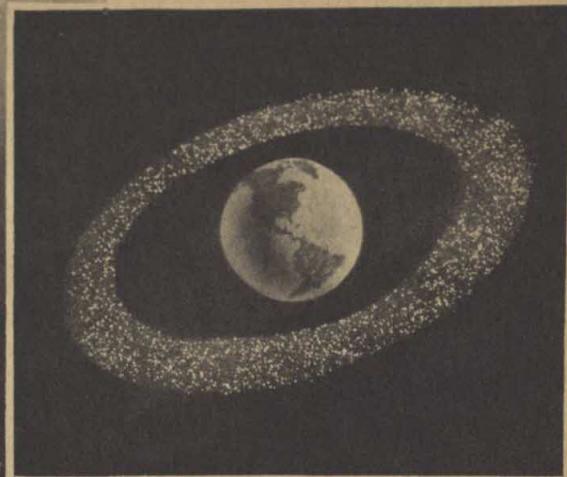
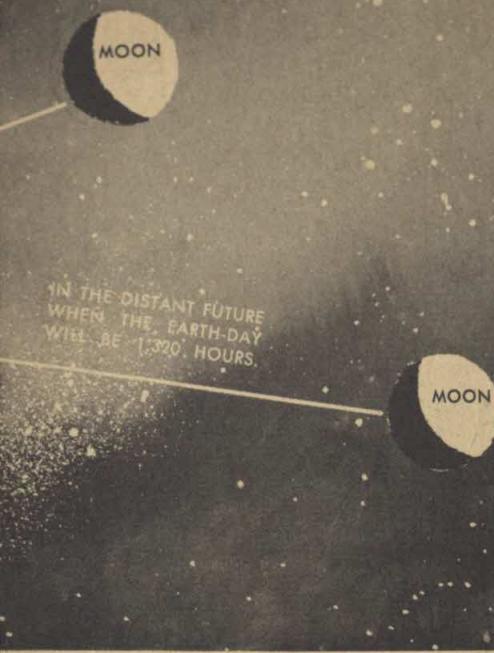
of the earth's oceans. The result was that the moon's period of rotation on its axis became exactly the same as its period of revolution around the earth.

Now, as the earth's rotation becomes slower (even by only 1/1,000th of a second in 100 years), the orbit of the moon becomes proportionally larger. Thus the moon's distance from the earth increases, and the moon-month becomes longer.

These changes due to tidal friction have been going on for billions of years, just as they are still going on. The earth-day, which was originally less than five hours, has lengthened to 24 hours. And the moon-month, which was originally the same length as the earth-day, has increased to about four weeks.

Astronomers now calculate that the slow lengthening of the earth-day will continue until it is as long as 55 of our present days, and the moon-month will also increase to 55 of our present days. At that time, the earth will always keep the same side toward the moon, as the





In many billions of years the moon will be pulled back toward the earth, and disintegrate upon entering the earth's atmosphere. Then its particles will form rings much like the rings around Saturn.

moon now keeps the same side toward the earth. If at that far distant time, the oceans of the earth still exist — and if they are still in a liquid state — there will be a constant high tide on the earth under the moon. Therefore there will be no more tidal friction produced by the moon. The moon and the earth will go around their common center of gravity as though locked together. The lengthening of our earth-day will cease when it has become equal to 55 of our present days.

When this balance point has been reached, the earth's rotation will gradually slow down until it is longer than the moon-month. Now the earth-moon relationship will be reversed. The earth's rotation will again speed up, and that of the moon will begin to slow down. Thus, the moon will gradually return toward the earth.

This process will continue until the moon is at last dragged down to within such a short distance of the earth that it will be broken up by the action of the

earth's tidal pull. Instead of colliding with the earth, the particles of the shattered moon will collect together and form a series of rings around the earth much like the rings of the planet Saturn — although the rings will be much more massive.

But all of these amazing things will not happen until many billions of years in the future.

When the full moon moves into the deep shadow of the earth and seems to disappear, we call it the *eclipse* of the moon. There are usually one or two such lunar eclipses that are visible in the United States each year, and almost everybody has observed at least one in his lifetime. Most of us enjoy watching the spectacle of the moon being apparently swallowed up by the earth's shadow.

But in ancient times, people did not know what caused eclipses, and they were frightened by them. Even today,

**What is an
eclipse?**

among some of the more primitive tribes in Africa, an eclipse causes great terror.

A story states that on his fourth voyage

**How did an
eclipse save
Columbus?**

to the New World in 1504, Christopher Columbus saved himself and his crew by his

knowledge that a lunar eclipse was coming on a certain night.

Columbus badly needed supplies for his ships, but the Indians refused to get them for him. He then told the Indian chiefs that the Christian God was angry because they had refused their help; that He would punish them with famine; and that as a sign of His anger He would remove the moon from the sky.

When the eclipse began as Columbus

had said it would, the Indians were panic stricken. They promised to furnish all the provisions he wanted if he could persuade his God to give the moon back to them. When the eclipse had passed, the Indians complied.

Since astronomers are able to figure

**In what year
was Jesus born?**

backwards and determine the dates of lunar eclipses in the far distant past, they have been able to establish accurate dates for a great many historical events.

An eclipse of the moon took place on the night before the death of the Judean King Herod who, during the final year of his reign, ordered the death of all male children in Bethlehem. He had hoped that the baby Jesus would be killed in the general slaughter. We know that this particular eclipse occurred on March 13, in the year 3 B.C. Thus we can conclude that Jesus was born at least four years before the calendar beginning of the Christian era.

The earth orbits around the sun in a

**What causes
an eclipse?**

level plane. For example, if we suppose that the sun is in the center of a dining-room table, then the earth moves around it on the same level as the table's top. On the other hand, as the moon goes around the earth its path is tilted about five degrees. That is why we do not have an eclipse during each full moon. The earth, of course, always casts a shadow which extends nearly 859,000 miles into space, but the moon ordinarily passes above or below it. However, when the moon is in the same



A lunar eclipse occurs when the moon passes through the earth's shadow. Usually in a lunar eclipse, the moon appears darkened to a deep copper red.

When will the next eclipse occur?

Here is a schedule of lunar eclipses which can be observed in the United States during the next ten years.

1963 — December 30
1964 — June 25
December 19
1965 — June 14
1967 — April 24
October 18
1968 — April 13
October 6
1970 — February 21
August 17
1971 — February 10
August 6
1972 — January 30
July 26
1973 — December 10



plane as the earth during full moon, the earth's shadow blots out the moon and an eclipse occurs.

An eclipse of the sun takes place during

What is an eclipse of the sun?

the new moon when the moon is between the earth and the sun. The shadow cast by the moon varies in length from 228,000 to 236,000 miles. For this reason, most of the times when the moon is in the right position for a solar eclipse, the moon's shadow does not reach the earth.

On the other hand, when new moon occurs during perigee (when the moon is at the lowest point in its orbit), the

moon's shadow extends several thousand miles beyond the earth. On such occasions, the shadow cast by the moon onto earth may cover an area of some 475 sq. miles.

It is for the above reasons that eclipses of the sun are rare and fleeting events. They last for only a few minutes, and take place at many different points over the earth's surface. If, for example, astronomers know that a solar eclipse is scheduled to occur at Kano, in Africa, on a certain date, they will spend many many months setting up their equipment at that location in order to take photographs of the phenomenon.

In ancient China and Egypt, the high priests taught the people that when an eclipse came an evil dragon-spirit was



A solar eclipse occurs when the moon passes between the earth and the sun, blocking view of the sun from a section of the earth.

eating up the sun, and it would disappear forever unless prayers were said and offerings were made. Other magicians and sorcerers, knowing that an eclipse was due, threatened to remove the sun from the sky unless certain of their demands were met. When the eclipse began, the people were convinced that the magician was making good his threat. After they gave him what he wanted, he would promise to make the sun reappear in a few hours, which of course it was going to do in any case.

If you are ever lucky enough to see a total solar eclipse, you will discover that it is an awe-inspiring sight. As the moon approaches the sun, the skies begin to darken as they do at normal twilight. On the farms, chickens go to roost, thinking that it is nightfall. When the moon completely obscures the sun's flaming ball, the sky becomes almost as dark as a moonless night. Then, in a few minutes, the moon passes across the sun and disappears from view, and the day becomes bright again.

Galileo, the first man to look at the moon with a magnifying telescope.

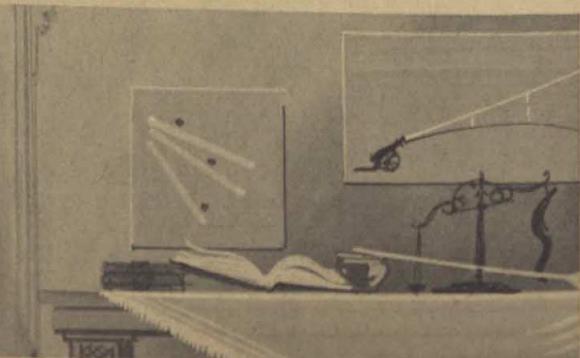


Ever since the dawn of history, men have been gazing up at the moon and speculating about it. Because they could see it no better than we can with the naked eye, they were not able to tell much about it. The first man who viewed a fairly good close-up image of the moon was an Italian scientist named Galileo Galilei. He is known to history by his first name.

As a scientist, Galileo was far ahead of his time. When he was only nineteen, and a student at the University of Pisa, he observed the slow swinging of a lamp suspended from the high ceiling of a cathedral. From this he developed the theory of the pendulum, and was the first to apply it to the measure of time. According to legend, by dropping metal balls of different sizes from the leaning tower of Pisa, he proved that weight has no influence on the velocity of falling bodies. He also determined the acceleration of falling bodies.

Galileo became interested in observing the heavenly bodies, but was frustrated because he could not get a clearer look at them.

Then, in 1609, he learned that a Dutch spectacle maker named Jan Lippershey had built a gadget that consisted of several lenses put together



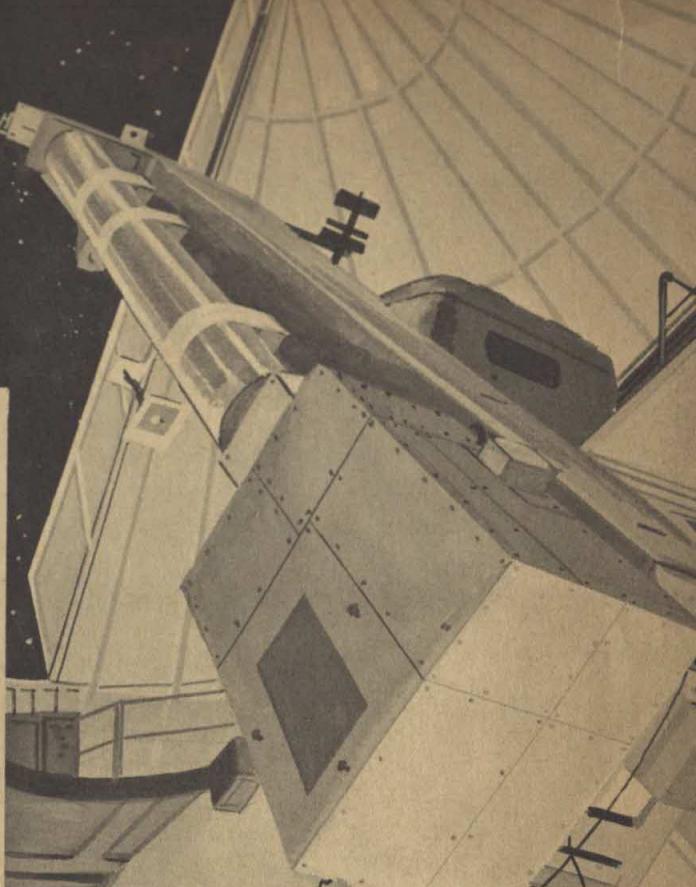
The telescope used by Galileo advanced knowledge about the moon considerably. Today, cameras mounted on powerful telescopes in our great observatories are able to take remarkably clear pictures of the surface of the moon. These cameras are capable of making accurate photographs of objects on the moon-scape that are only about a half-a-mile in length. For this reason, no major moon-mark (as compared to landmark) has gone undetected.

inside a tube. It made distant objects such as trees or people appear to be quite close. Lippershey called it the "magic tube." Galileo quickly jumped at this novel idea. He refined the lenses, adjusted their positioning inside the tube, and so built a telescope.

We can imagine how excited he was when he first turned his telescope on the moon. For the first time, he saw its craters, its mountain ranges, and its huge expanses of broad flat plains. Since these latter areas appeared smooth and featureless, as would large bodies of water, he called them seas.

For the rest of his busy life, Galileo spent a good part of his time studying the heavens. He greatly expanded his observations of the moon. He observed the dark spots on the sun through his telescope. He discovered the crescent of Venus and the four moons of Jupiter, and concluded that the hazy fog of the Milky Way actually consisted of millions of separate stars.

Of course, Galileo's first telescope was a crude and primitive affair, but it was the great grandfather of the huge telescopes that tell us so much about the moon's surface today.



The earth rotates on its axis in a west to east direction once every 24 hours, thus causing night and day.

Why do we see only one side of the moon?

The moon rotates on its axis and in the same direction to produce night and day on the moon. But there is one great difference between the two bodies. The moon rotates on its axis only once every $27\frac{1}{3}$ days, or, once during each time it orbits the earth.

Thus, the speed of the earth's rotation is about 1,000 miles per hour at the equator while the moon's rotation speed at its equator is only 10.35 miles per hour. These two rotation speeds are so delicately adjusted that the same half of the moon is always turned towards the earth. We call this the "earth side" of the moon. The half that we never see is called the "far side."

You can make a simple experiment

that explains why we always see the same side of the moon. Place some object, such as a chair, in the center of a room, and assume for the moment that it is the earth and you are the moon. Now walk slowly around the chair in a counter-clockwise direction. When you have made one complete circle, you will observe that your body has rotated once in relation to the walls of the room. But only the left side of your body has been turned toward the chair. The right side of your body has always been hidden from it.

If the moon orbited the earth in a perfect circle, we would see exactly fifty percent of its surface and no more. But since its orbit is that of a slight ellipse — that is, a little bit higher at the apogee and lower at the perigee — it appears to "wobble" in its passage.

When the moon's axis is thus tilted toward us, we can see a few degrees beyond its north pole. When it is tilted away from us, we are able to see a few degrees beyond its south pole. In the same way, we can also observe several degrees beyond the eastern and western edges of the moon's "near side." Thus, at various times, we can see roughly sixty percent of its surface, or ten percent more than its true "earth" side.

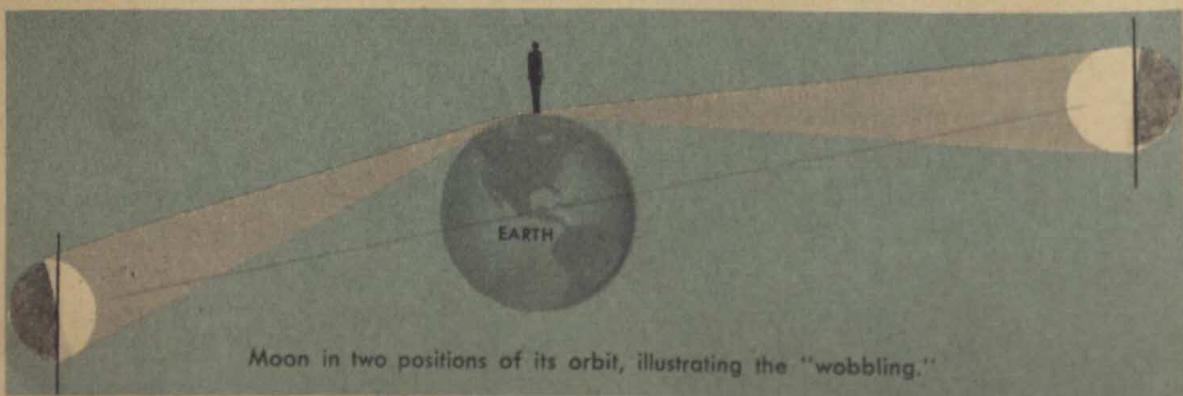
Until 1959, no one had any definite idea at all about what the "far side" of the moon might look like. In that year,

**How can we
see the moon's
"far side"?**

Russian scientists successfully sent up a moon probe, called Lunik III, which circled the moon one time. On its journey around the "far side," cameras on Lunik III made photographs that were transmitted back to laboratories on earth. These pictures revealed about half of the unknown portion of the moon's surface, leaving only about twenty percent of which we have no knowledge at all.

Obviously, the photographs made by Lunik III are not nearly as sharp and clear as those made of the "earth side" by observatory cameras.

Only a few formations stand out in legible detail. For the most part they are too blurred to furnish accurate information. But, even so, the flight of the Lunik III was an amazing scientific break-through. The first American moon probe, Ranger, will probably have made a successful lunar voyage by the time you read this. Ranger is expected to provide much clearer pictures of what the moon's hidden surface really looks like.





The visible side of the moon. More than 30,000 craters are mapped, ranging in width from the largest, Baily, 183 miles in diameter, and Clavius, 146 miles, to the smallest photographed, $\frac{1}{4}$ mile in diameter. The deepest crater is Newton, 29,000 feet. The highest mountains, Leibnitz and Doerfel exceed 30,000 feet and are thus higher than the highest mountain (Everest) on earth. The largest visible valleys are Rheita Valley, 115 x 15 miles, and Alpine Gorge. The largest seas are Mare Imbrium (Sea of Showers) which covers about 340,000 square miles and Oceanus Procellarum (Ocean of Storms).

The principal features of the moon's

What is the
moon-scape like?

surface are its
mountain ranges,
its craters, and its
seas. Almost all of them have been
given names for identification.

The sea areas, first observed by the
earliest astronomers like Galileo, were
given Latin names: *Oceanus Procel-
larum* (Ocean of Storms), *Mare Im-
brium* (Sea of Rains), *Mare Humorum*
(Sea of Moisture), *Mare Nubium* (Sea

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of Clouds), *Mare Vaporum* (Sea of Vapors), *Mare Tranquillitatis* (Sea of Tranquillity), *Mare Foecunditatis* (Sea of Fertility), *Lacus Somniorum* (Sea of Dreams), and many others.

For the most part, the important mountain ranges were named for mountains on earth: Alps, Apennines, Caucasian, Jura, Carpathian, Pyrenees. Others, such as Leibnitz and Doerfel, were named for famous astronomers.

The craters also took their names from great scientists and philosophers, both ancient and modern: Plato, Copernicus, Euclid, Archimedes, Faraday, Cavendish, Ross, Pickering, Lee, Newton, and scores of others.

When the Russians made the first charts of the moon's "far side," they named the outstanding new features which they discovered: Moscow Sea,

Soviet Mountains, and Tsiolkovsky, Lomonosov, and Tsu C'hung-Chin craters.

The mountains on the moon were prob-

**What are the
mountains on
the moon?**

ably formed when the moon was in the process of changing from a liquid to a solid and its interior was molten. As it cooled, the surface wrinkled and cracked like a dried-up skin of a prune. It was in this same way that the mountains on earth were originally created.

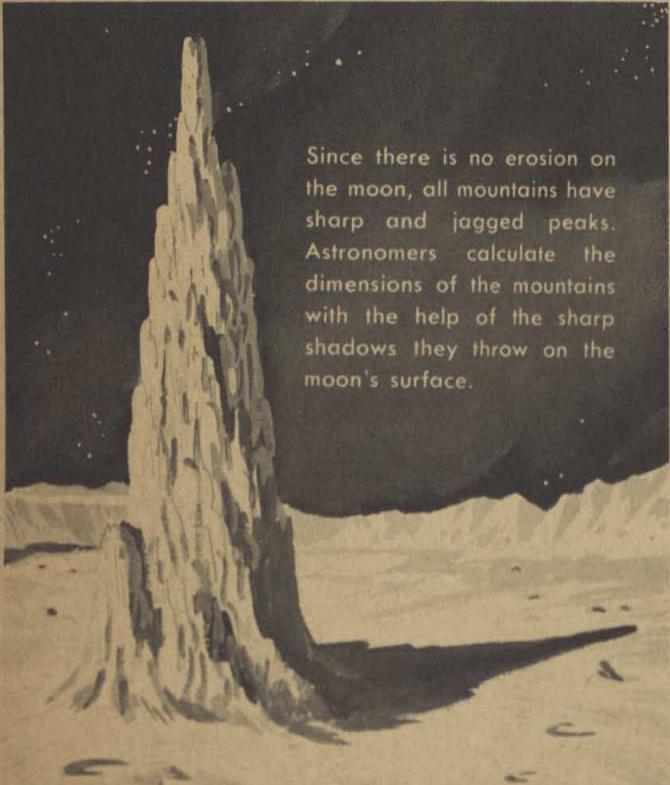
At one point, the Leibnitz Mountains tower 29,000 feet above their base. This is as high as Mt. Everest, the tallest mountain on earth. Recent calculations, which have yet to be confirmed, indicate that some moon mountains may exist which are even higher.

Altogether, some 30,000 craters have

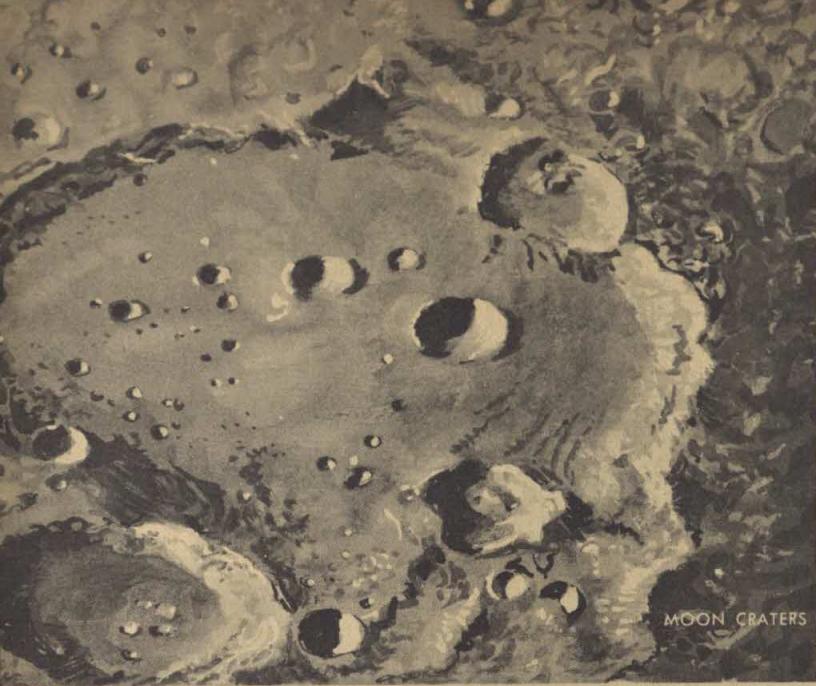
**What are
the craters?**

been counted on the moon. These range in size from the crater with a diameter of as much as 150 miles from rim to rim, to comparatively small pock-marks less than half a mile in diameter. The crater, Clavius, for example, is about 146 miles in diameter. If you were standing in its center, its rims would be invisible, completely hidden from view beyond the short lunar horizon.

Scientists have no way of knowing exactly how these craters were created. It is believed however that some of the smaller ones may have been the result of volcanic activity during the moon's formative stages. Indeed, a few years ago, one astronomer observed what he

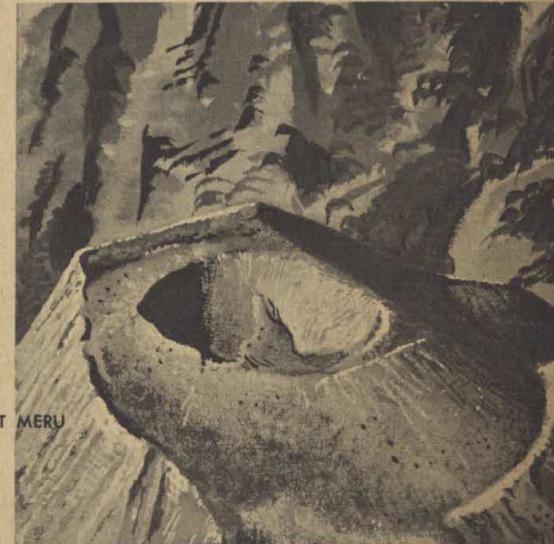


Since there is no erosion on the moon, all mountains have sharp and jagged peaks. Astronomers calculate the dimensions of the mountains with the help of the sharp shadows they throw on the moon's surface.

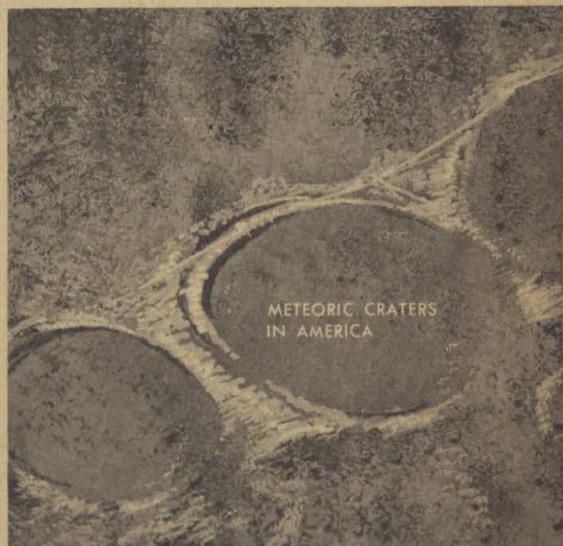


MOON CRATERS

Close-up of moon craters in the region of Clavius as compared with Mount Meru Crater, an unusually well-rounded volcanic crater on earth (Tanganyika, Africa) and meteoric craters in the United States. The comparison supports the theory that most moon craters were caused by giant meteors.



MOUNT MERU



METEORIC CRATERS
IN AMERICA

believed to be an outburst of gas from the inside of the crater Alphonsus. If this observation was correct, it would indicate that the interior of the moon is still hot and gaseous, and that a possibility of volcanic activity on its surface still exists.

Since only a few lunar craters resemble earth volcanic-craters, it is supposed that most of them were caused by the tremendous impact of large meteors striking from outer space. Some scientists believe that a meteor hitting the surface of the moon at an angle would make an elliptical crater that becomes round due to the heat of impact. Other scientists argue that whatever the angle of impact, the crater would be round. The craters on the moon are mostly round.

The size of the meteors that created the larger craters must have been enormous, triggering explosions many thousands of times greater than the most powerful nuclear bomb. The moon is constantly being bombarded by meteors, both large and small.

The earth, too, is under a constant

meteor bombardment. But when a meteor approaches earth, it is burned up and vaporized as it comes into contact with the heavy layers of atmosphere. The larger ones we see as "shooting stars." Sometimes, if the meteor is originally large enough, a small core of it survives and lands on earth as a chunk of metal.



Some of the circle-craters, like Copernicus for instance, have huge central peaks and show conspicuous landsliding of the inner slope.

But since the moon has no atmosphere, a meteor can strike it with full force, and thus gouge out a big depression on the surface.

The winds and waters of earth are constantly at work to change the earth's surface and erase the marks of its geologic history. But the moon is without the erosive effects of wind and water. Thus, it is almost certain that every scar inflicted on the moon's surface in the past two or three billion years remains exactly as it was when it was first made.

Scientists have not observed any new craters of appreciable size that have been created on the moon since the invention of the telescope. From this we might conclude that the meteoric bombardment of the moon — especially by giant meteors — has not been as great in the last few hundred or few thousand years as it was in the distant past.

Rills are less prominent features of the lunar surface. They are cracks in the rock, some shallow and some deep, extending in length from one or two miles to several hundred. These cracks were probably created when the surface of the moon cooled.

What are rills?

We know very little about the rills because, compared to the mountains and craters, they are too small to furnish much accurate data for our earth cameras to record in detail. We know that they exist, and that is about all we do know about them.

One of the most puzzling mysteries of the moonscape are the rays. These are bright streaks that fan out in all directions from some of the bigger craters, notably Tycho, Copernicus and Kepler, and from many of the smaller ones as well. Some of these rays emanating from Tycho are so long that they extend more than 2,000 miles from the crater and disappear over the horizon into the moon's far side.

No one has ever been able to determine just how these rays were originally formed, or what they consist of. The most popular theory is that they are long streamers of moon dust that were scattered by the meteors that formed the craters.

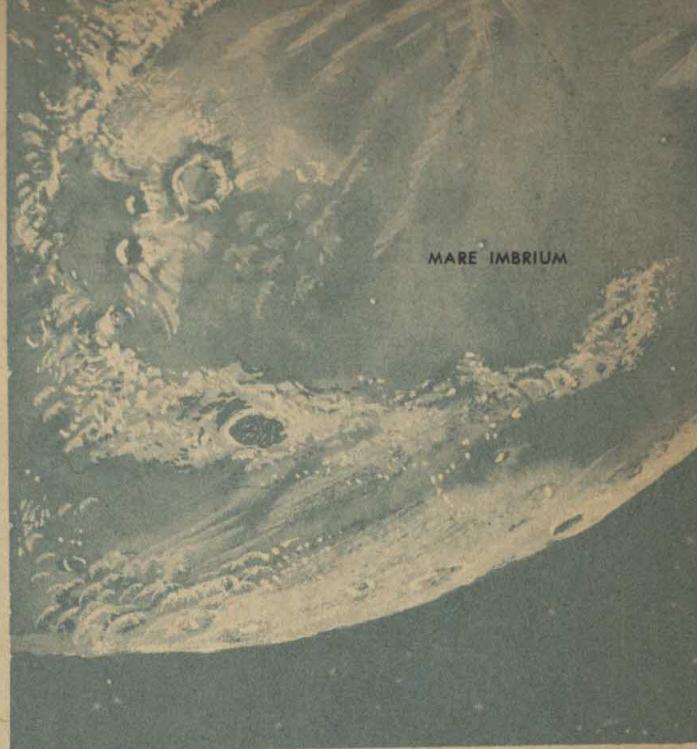
You can see how this might have happened if you place a small pile of fine face powder on a piece of dark paper and then strike it sharply with

The seas, like the *Mare Imbrium* shown here, have no water. At top left, are the Apennine Mountains.

the round side of a spoon. The powder will fly out in all directions in precisely the same pattern as that of the rays we can see on the moon.

Since there is no air or wind on the moon to disturb these dust patterns, they would have remained exactly as they were when they were originally made.

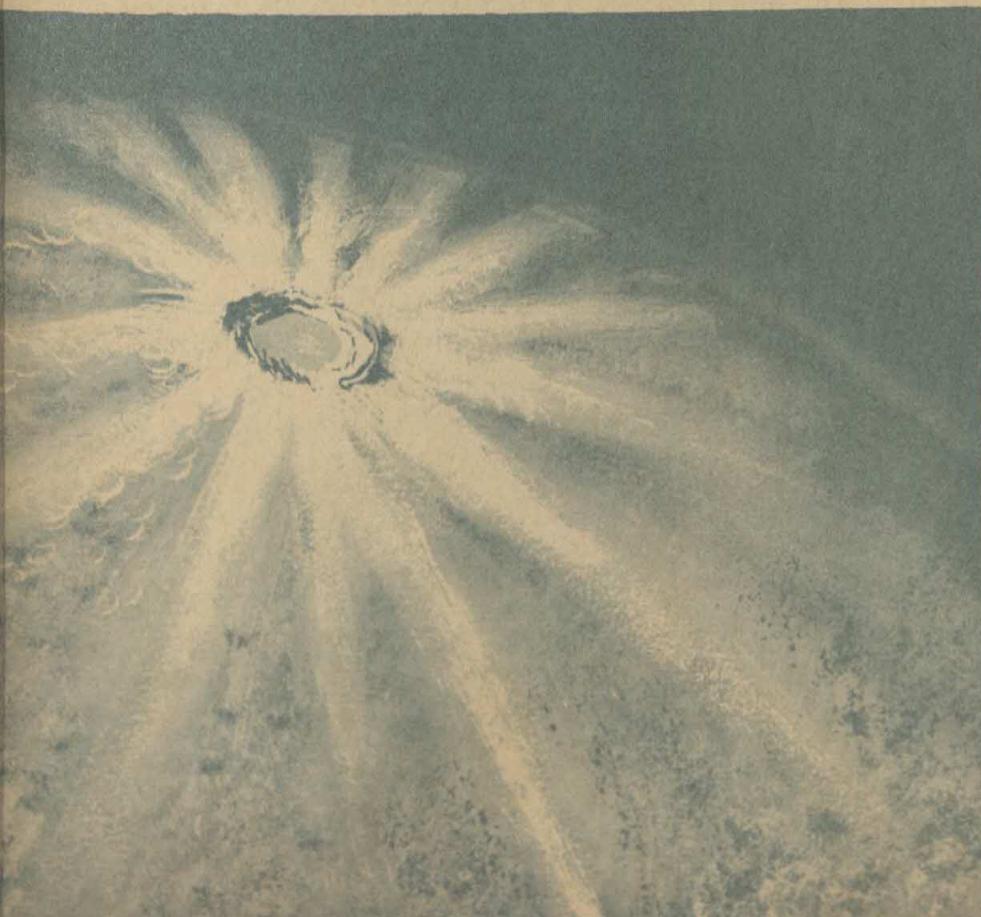
Another theory holds that the rays may be composed of a lighter-colored sublunar material that was blasted from the crater by the meteor. The heat of the meteor's impact and explosion may have melted and fused this material into a glass-like form. Such glass particles would reflect light, and thus might account for the fact that rays vary in brightness as phases of moon change.



MARE IMBRIUM

The great level plain areas of the moon are called "seas." The earliest astronomers, gazing at the moon with their primitive telescopes, did not

**What are
the "seas"?**



The rays emanating from the bigger craters are puzzling mysteries. Shown here is Tycho with rays extending more than 2,000 miles from the crater and disappearing over the horizon into the moon's far side.

know that the moon was a lifeless, waterless body, and reasoned that parts of its surface must be covered by water like the seas on earth. We know now that the "seas" are dust-covered deserts, but they have been allowed to keep their original designations as "seas." And indeed at one time, when the moon was being formed, they were probably actual seas of molten lava.

Since the "seas" are flat and apparently less hostile than the more rugged mountain areas of the moonscape, it is here that the first spaceships from earth, both unmanned and manned, are expected to make their initial landings.

Earth telescopes, as we have seen, can

**What do we
know about the
moon's surface?**

provide us with fairly accurate details of the larger features of the

moon's surface. But since telescopic lenses cannot clearly focus on any object less than half-a-mile long, we do not know for certain what the surface is like. Much of our knowledge of the close-up details of the lunar surface depends upon the analysis of radar echoes and reflected sunlight. A large part is also educated guesswork, based on reasoning and logical surmise. For this reason, many astronomers differ widely as to their opinion of the precise details.

All scientists are in agreement that the moon is covered by a layer of dust, created by the impact of meteorites and by the disintegration of the moon-rock. This disintegration results from the violent and extreme changes in temperature. The earth's surface rocks crumble into dust due to the same causes.



Some believe that the dust layer is only a few inches to a few feet deep. Others hold that it may be several hundred feet deep. The general consensus is that the thickness of the dust layer varies; it is probably very deep inside the craters, but relatively thin on the broad flat areas of the "seas."

When the first Russian moon-shot crashed on the lunar surface a few years ago, one Soviet scientist reported that it kicked up a shower of dust that arose to a height of nearly 500 miles before settling back. If this is true, it would indicate that the depth of the dust cover is considerable.

A very thick layer of dust would be





Pale earth-light shines in this artist's conception of an extreme close-up of a giant lunar crater with terraced walls. The smaller craters in the dust-covered floor are younger.

a terrible hazard to the first manned spaceship. Upon landing, its retro-rockets could blow a hole in the dust layer that would completely bury the ship and its occupants. One of the essential jobs of the unmanned moon-ships will be to determine exactly the thickness of the moon's dust cover.

There are many other scientific theories about the make-up of the moon's surface. It has been suggested that the radiation from the sun has hardened the upper layers of dust into a crust on which a spaceship could land and explorers could walk. Another theory states that ceaseless solar radiation over a period of billions of years has turned

the moon's dust into a sort of frozen foam into which a ship or a man would sink to frightful depths.

One scientist has advanced the theory that the moon may be covered, at least in part, with thin, bristle-like stalagmites of hardened lava known as Pele's hair. These are often found after the eruption of volcanoes in Hawaii. On earth, wind erosion makes short work of such stalagmites. But on the moon, with no wind to affect them, they would be permanent fixtures.

One of the tasks of the first unmanned moon rockets will be to get as many answers as possible to the question of what the moon's surface is really like.

If we accept the most popular scientific

**Do air and
water exist on
the moon?**

theory, namely that the moon and earth were formed at the same time and of the

same basic material, then we can theorize that they probably followed the same basic pattern of evolution. In this case, the moon once had an atmosphere, and also a form of water.

Why, then, if this atmosphere and water remained on the earth, did it not also remain on the moon? Most scientists believe that the answer lies in the difference between the force of the earth's gravity and that of the moon's.

The pull of the earth's gravity keeps our atmosphere and water from escaping into space as the earth rotates. But the moon's gravitational pull was not strong enough to hold onto its own atmosphere. Therefore, over millions of years, its air and moisture escaped into the void of space.

There is, however, a trace of atmosphere on the moon: a few gaseous molecules that cling to cracks in the surface. At the most generous estimate, this atmosphere amounts to no more than one-millionth that of the atmosphere on the earth's surface. This would roughly be equal to the air pressure that exists 70 miles above the earth. So, for all practical purposes, we may assume that the moon is a cold, lightless, airless, waterless globe.

Moon explorers, then, will have to wear clothing that not only provides them with an oxygen supply, but which also protects them from the total lack of air pressure as well as the extremes of heat and cold.

Since the moon is airless and waterless,

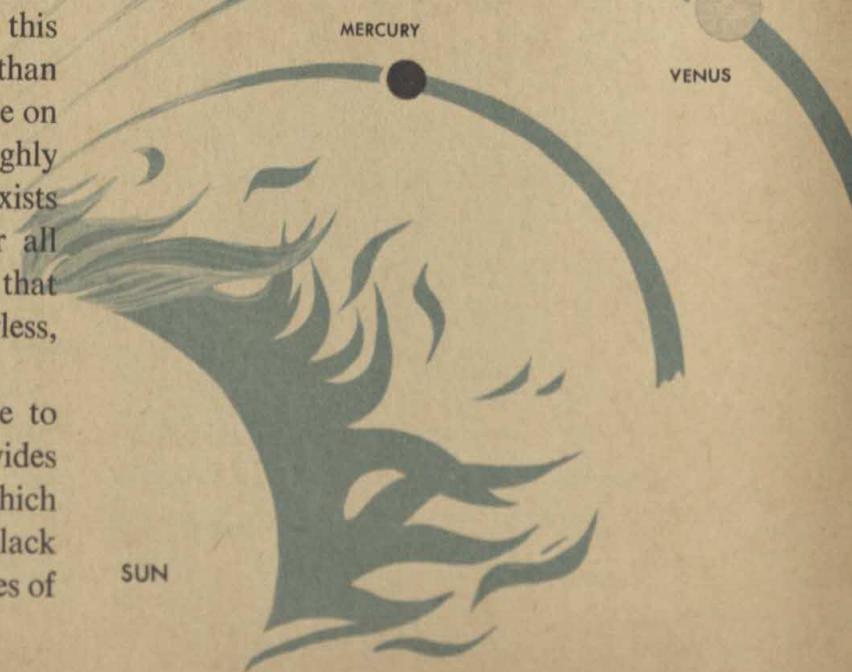
**Does life exist
on the moon?**

it is generally supposed that it is also entirely lifeless.

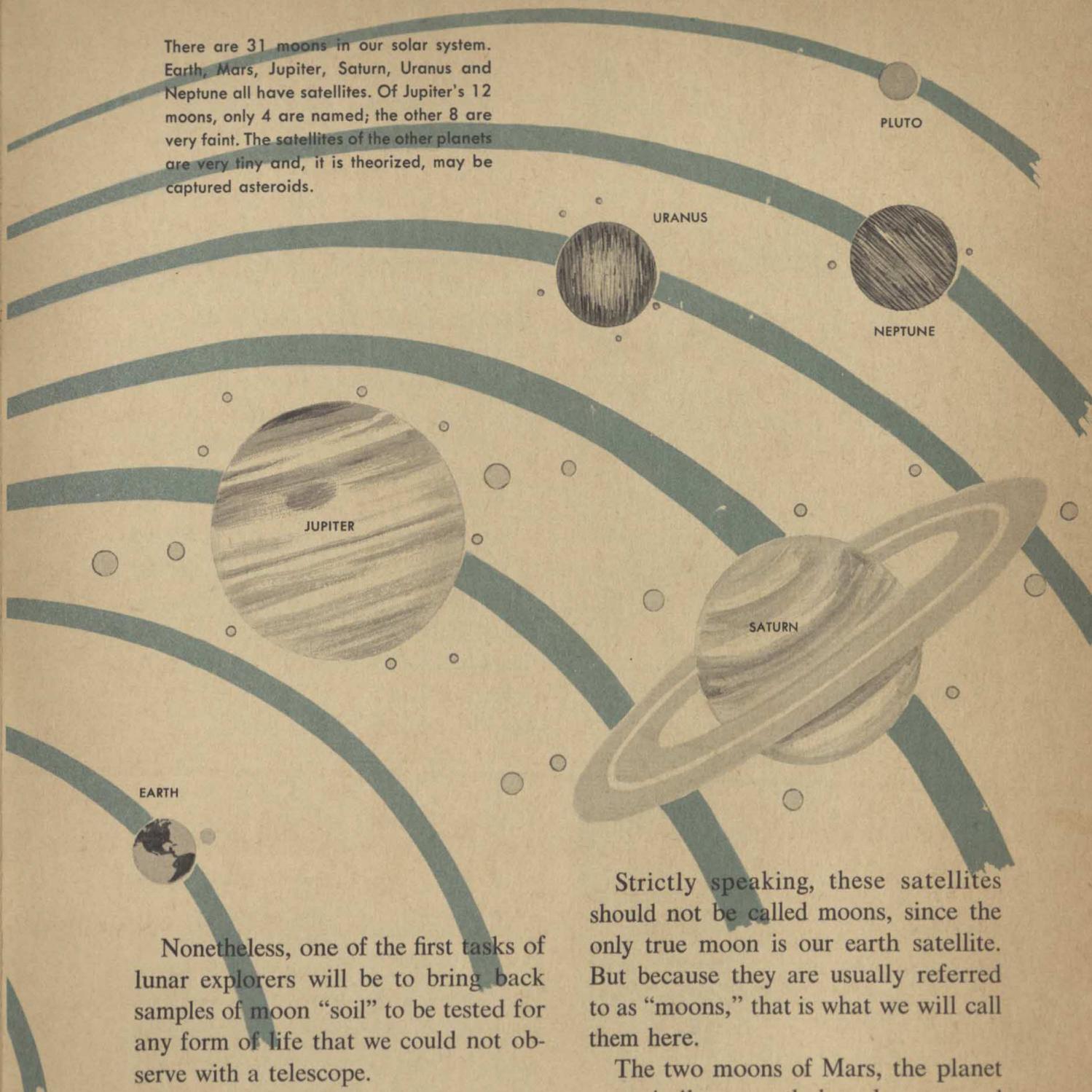
However, as in most things concerning the moon, there have been differences of opinion.

Some scientists have proposed that the changes in color that occur in certain moon craters may be due to a species of vegetation that grows there during the hot moon-day. Presumably, if such vegetation exists, it freezes up during the cold moon-night, and then comes back to life when the sun shines again. This cycle would be comparable to that of trees on earth, which appear lifeless during the winter, and leaf and blossom again in the spring.

One astronomer observed moving patches on at least one of the crater floors. He reasoned that these might be swarms of some kind of insects, feeding on the vegetation. Most authorities, however, agree that any sort of life on the moon as we know it is impossible.



There are 31 moons in our solar system. Earth, Mars, Jupiter, Saturn, Uranus and Neptune all have satellites. Of Jupiter's 12 moons, only 4 are named; the other 8 are very faint. The satellites of the other planets are very tiny and, it is theorized, may be captured asteroids.



Nonetheless, one of the first tasks of lunar explorers will be to bring back samples of moon "soil" to be tested for any form of life that we could not observe with a telescope.

As far as we know, there are thirty moons, other than

**Are there other
moons in our
solar system?**

Solar System. Mars has 2; Jupiter 12; Saturn 9; Uranus 5; and Neptune 2.

Strictly speaking, these satellites should not be called moons, since the only true moon is our earth satellite. But because they are usually referred to as "moons," that is what we will call them here.

The two moons of Mars, the planet most similar to earth, have been named Deimos and Phobos. Both are very tiny: Deimos is only five to ten miles in diameter and Phobos is about twice that size.

We know that the "escape velocity" from earth — the speed necessary for a space vehicle to fling itself loose from

the earth's field of gravity — is about 25,000 mph. Only the most powerful rockets in our NASA supply are capable of such a tremendous thrust. But the gravity on Deimos is so weak that a man could jump clear off the tiny moon, hurling himself into space by the power of his leg muscles alone. Any future astronaut who might happen to land on Deimos, will have to be very careful, or he may find himself floating free in outer space.

Because these moons of Mars are so small, a curious theory has been advanced to account for them. Mars appears to be a dying planet, and some people think it once had an atmosphere like ours and was populated by intelligent beings. When the atmosphere thinned out, making life on the planet impossible (so the theory goes), the Mars-men built two giant spaceships in which they could continue to live under artificial conditions, and put them into orbit. These man-made moons are Deimos and Phobos — if the fantastic theory is true.

Galileo, as we have learned, discovered the four largest moons of Jupiter. These have been named Io, Europa, Ganymede, and Callisto. Io is about the size of our moon; Europa is slightly smaller, and the other two are slightly larger. The first three seem to be made of rock, like our moon, but it is possible that Callisto may be a solid ball of ice, or perhaps a rock core covered with ice.

During recent years, astronomers have detected eight more moons orbiting around Jupiter. All of them are small, ranging in size from 20 to 150 miles in diameter.

Saturn has nine known moons. The largest one, Titan, is the biggest moon in our solar system. It is about the size of Mars, and appears to have an atmosphere of its own, probably composed of methane gas. It is believed that some of Saturn's smaller moons may be, like Callisto, nothing but balls of ice.

In addition to its nine moons, Saturn also is surrounded by a spectacular ring. This ring is composed of billions of tiny moons, ranging in size from specks of dust to baseballs. Since the rings are good reflectors of light, it is thought that they too are tiny ice balls or ice-covered rocks.

We know very little about the moons of Uranus and Neptune, except for the fact that Uranus has five and Neptune two. The smaller of Neptune's moons, Neireid, is only about 200 miles in diameter. The larger, Triton, is a giant, its diameter being between 3,000 and 5,800 miles.

But of all the moons in the sky, the one that interests us most is our own.

If we accept the theory that the moon was formed from the same basic materials as the earth, then we may assume that it contains much of the same elements that are found on earth: iron, aluminum, lead, nickel, nitrogen, hydrogen, etc. One of the main reasons for sending manned spacecraft to the moon will be to determine exactly what kinds of metals and minerals do exist there; in what quantities they are to be found; and what is the best way to mine them.

The metal deposits of the earth are

Does the moon contain valuable minerals?

gradually diminishing, although it will probably be thousands of years before they are completely exhausted. But scientists look to the deposits on the moon to provide raw materials for earth's industries well into the distant future.

One leading authority has suggested that large deposits of ice and water may lie only a few dozen, or a few hundred, feet beneath the lunar surface. If this is so, these deposits can furnish supplies of water for moon explorers to drink — and, by the relatively simple process of electrolysis (the chemical breakdown of water into its component parts of hydrogen and oxygen), supplies of oxygen for them to breathe.

For many centuries man has dreamed

**Why do we want
to explore
the moon?**

a wistful dream of someday going to the moon. But it

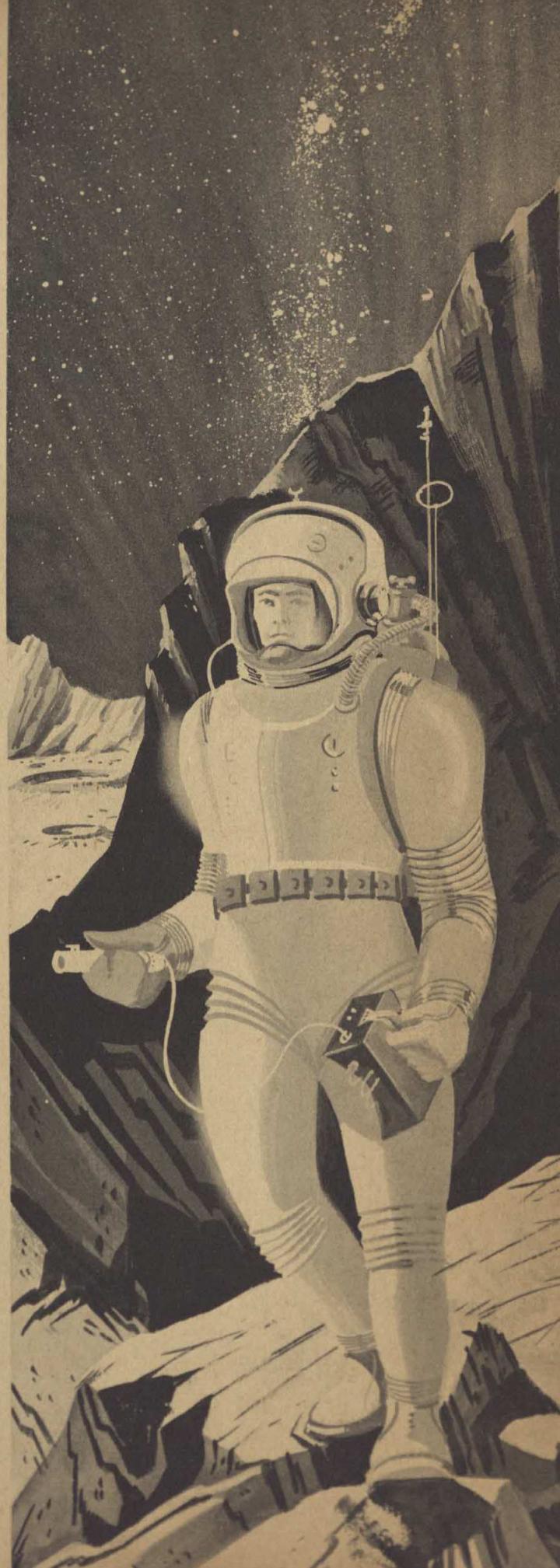
was not until the

past few years that modern developments in rocket engines have made such an attempt feasible. The United States National Aeronautics and Space Agency (NASA), and the Russian space agency, are already planning for the great adventure.

Many people have asked: "Why is it worth spending billions of dollars to land teams of explorers on the moon?" There are a number of reasons.

While astronomers already know a great deal about the surface of the moon, there is much that telescopes and radar beams cannot disclose. Is the dust

The moon-suit which was tested not too long ago in a lava crater in California, is pressurized and carries oxygen and food.



cover thin or thick? Is there a crust? Is the surface foamy? What kind of rocks, ores, and other minerals and elements does the moon contain? What is the "soil" of the moon like? Does it contain dormant life? What is the exact effect of solar radiation upon the lunar surface? Does the moon contain sub-surface ice and water?

Is it safe for human beings to fly through belts of radiation that may be deadly? Can spaceships travel through clouds of meteorites and other cosmic debris that whizz through space at velocities of up to 25,000 miles per hour?

Normally, the instruments of unmanned spacecraft can discover the answers to such questions as these more reliably than a man. But a machine can only do what it has been built to do. It cannot cope with the unexpected. Only man can handle the unforeseen. That is one reason why scientists feel that man must go to the moon.

The surface of the earth lies at the bottom of a deep, heavy sea of atmosphere. Through even the finest, most powerful telescopes that man has been able to produce, the pictures of the stars — and even of the moon itself — are more or less distorted.

The moon's almost total lack of atmosphere, and thus of atmospheric distortions, make it the ideal location for an astronomical observatory. Astronomers say that a relatively small 20-inch telescope on the moon would accomplish as much in probing the mysteries of outer space as the giant 200-inch telescope at Mount Palomar, the world's largest. And if a 200-inch telescope

could be placed in an observatory on the moon, the possibility of further discoveries would be endless.

It has been pointed out that the moon's surface, and every geological moon-mark upon it, has in all likelihood remained unchanged for billions of years. There has been no wind, no erosion, no weather to change them, as has been the case on earth. Therefore scientists are hopeful that this changeless record of the moon's history may go far to answer many of the puzzling riddles about the origin and development of the solar system as a whole.

With its low gravity and absence of atmosphere, the moon would be an almost perfect way-station from which to launch spaceships to the other planets. Less than one-sixth of the escape velocity would be required to lift a vehicle off the moon than would be needed to lift it off a launching pad on earth. This tremendous difference in pay-load would allow the ship to carry infinitely much more fuel for maneuvering once it was in space.

Already, our space scientists are looking forward to the day when the moon will become the earth's great spaceport.

As mentioned earlier, mineralogists believe that the ores and metals which are almost sure to be found on the moon

Artist's conception of a moon-city. Fantastic? Yes. But less so than Jules Verne's novel in 1874 "From the Earth to the Moon." One of the illustrations of the novel showed the moonship after landing, and the passengers observing the Universe (inset above).





can provide a nearly limitless source of raw materials for earth's industries. Once permanent landings have been made on the moon, methods of mining and transporting these minerals should quickly follow.

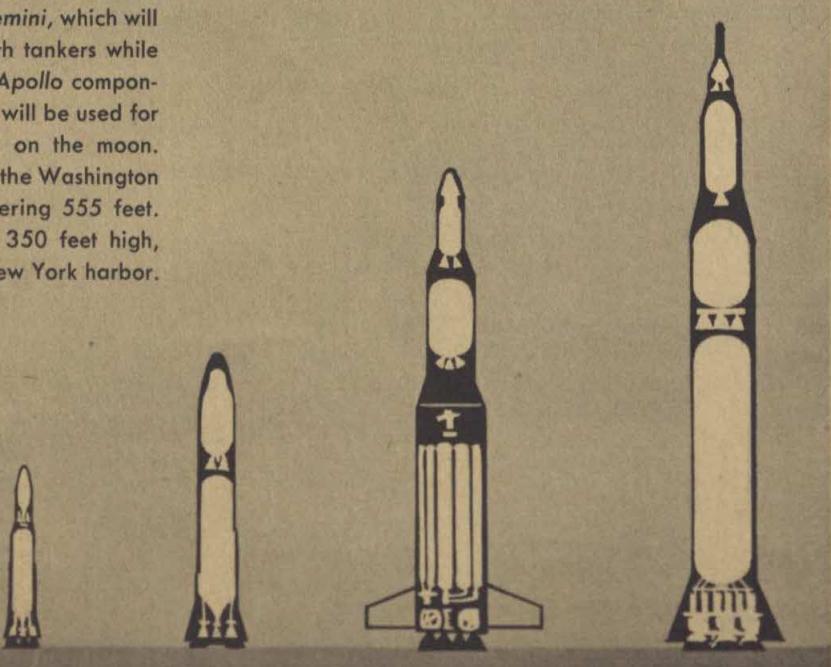
Finally, it has always been the nature of man to want to explore the unknown. Because of this urge, the early sea-farers found the New World; American pioneers discovered and developed the great country that lay over the western mountains; Arctic adventurers opened both the north and south polar areas to exploration.

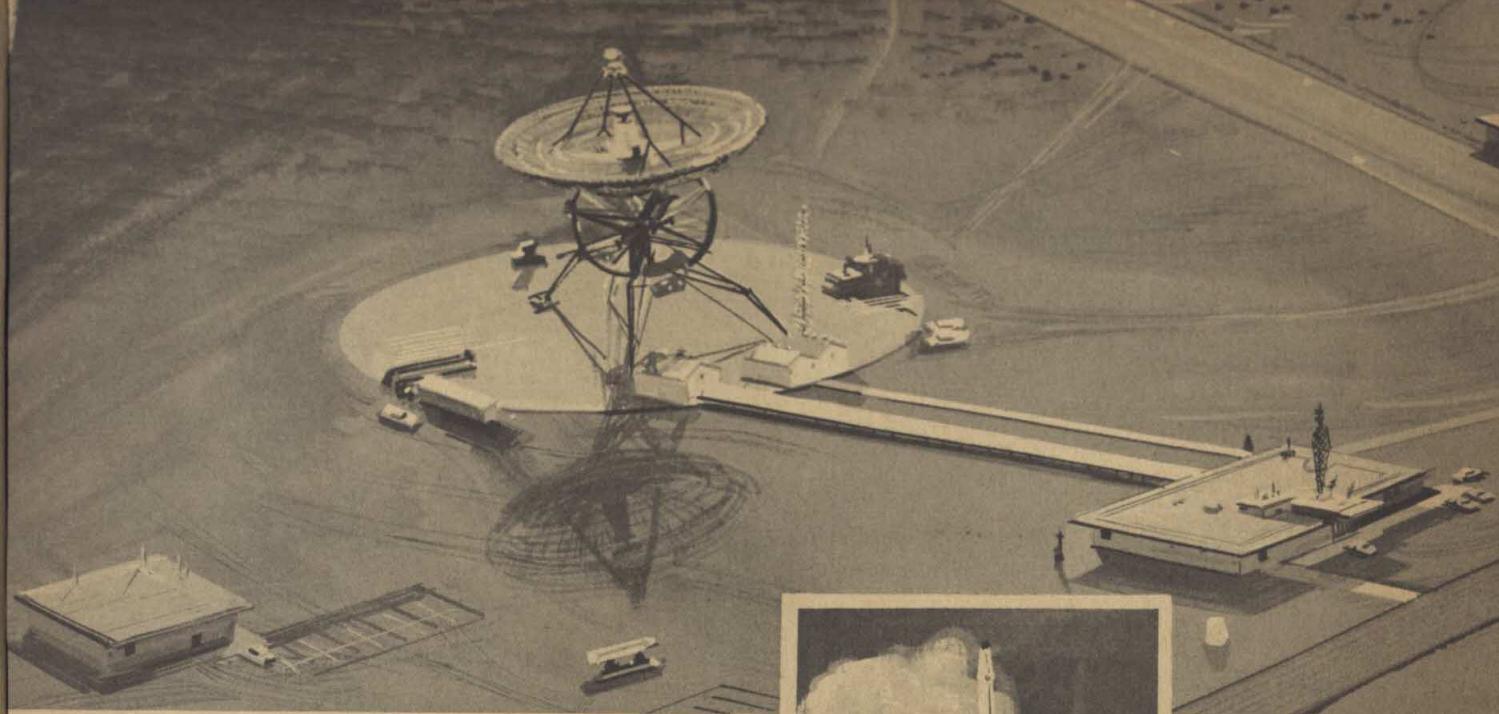
A famous mountain climber was once asked why he wanted to scale the dangerous heights of Mount Everest. He replied simply: "Because it is there." That is undoubtedly one of the reasons why men want to land on the moon. Just because it is there.

These are the missiles that are used to prepare the research and will be used to attempt the moon landing. From left to right: The *Atlas* used in *Project Mercury*, which sent our astronauts into orbit around the earth; the *Titan*, used in *Project Gemini*, which will perfect the techniques of meeting with tankers while in orbit; the *Saturn C-1*, used to test *Apollo* components and the *Advanced Saturn*, which will be used for *Project Apollo*, the manned landing on the moon. The missiles are compared in size with the Washington Monument in Washington, D.C., towering 555 feet. The *Advanced Saturn* will be about 350 feet high, higher than the Statue of Liberty in New York harbor.

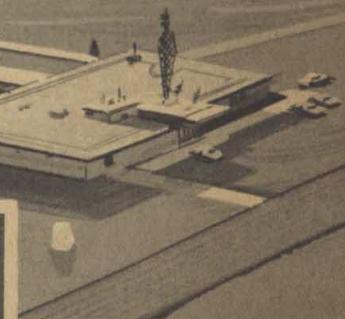
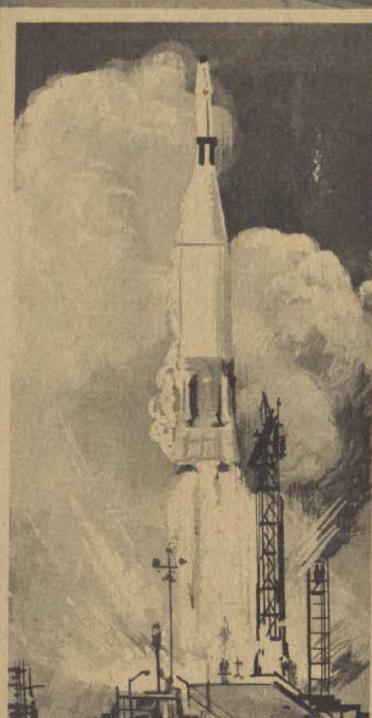
It is inevitable that the first crew of spacemen that lands on the moon will be likened to Christopher Columbus. And in many respects this will be true. They will have pioneered the way across a dangerous and forbidding sea — in this case the sea of space — and will have set foot upon a hostile soil that no man has ever seen before.

But whereas Columbus could only guess at what he would find, the pioneer spacemen will have a good idea of what to expect. In 1492, most men believed that the earth was flat, and that if a ship sailed to its edge, it would plunge off into some fearful, bottomless abyss and be lost forever. They also thought that the sea was guarded by fierce monsters that could swallow a ship and its crew at one gulp. Columbus did not believe these fanciful tales, but he had to risk his own life and the lives of his crew to prove that he was right.





The unknown into which our space-men will venture will present dangers much more real than those which Columbus faced. Even with as much knowledge as we already have about the moon, we still cannot be sure that a spaceship, making its first lunar landing, will not sink hundreds of feet into a quicksand of loose dust or frozen foam. We do not know the extent or deadly effects of solar radiation on the moon's surface. The answers to these and dozens of other questions just as vital can mean the difference between life and death to our moon pioneers. But whereas Columbus had to find out all the answers for himself, the National Aeronautics and Space Administration is planning to send out a series of robot spacemen, unmanned vehicles that are crammed with scientific instruments, to eliminate as much of the guesswork and danger as possible before the first men try for a landing. Already, the value of first sending *unmanned* craft to the moon has been amply demonstrated. Two such vehicles, aimed at a crash



Stations at Woomera, Australia and Johannesburg, South Africa, will help track the space vehicles and report to Goldstone (above), Southern California, the Ranger's command post. Orders to the space craft are sent, and television pictures and signals from Ranger are received, by an 85-foot dish antenna. At left the blast-off of an Atlas missile with Ranger 4 mounted above the second-stage Agena B.

landing on the moon, have thus far failed. The first one missed the moon by about 22,000 miles and went into permanent orbit around the sun. The second lost its power. In both cases, had they been manned by human crews, the crews surely would have been lost.

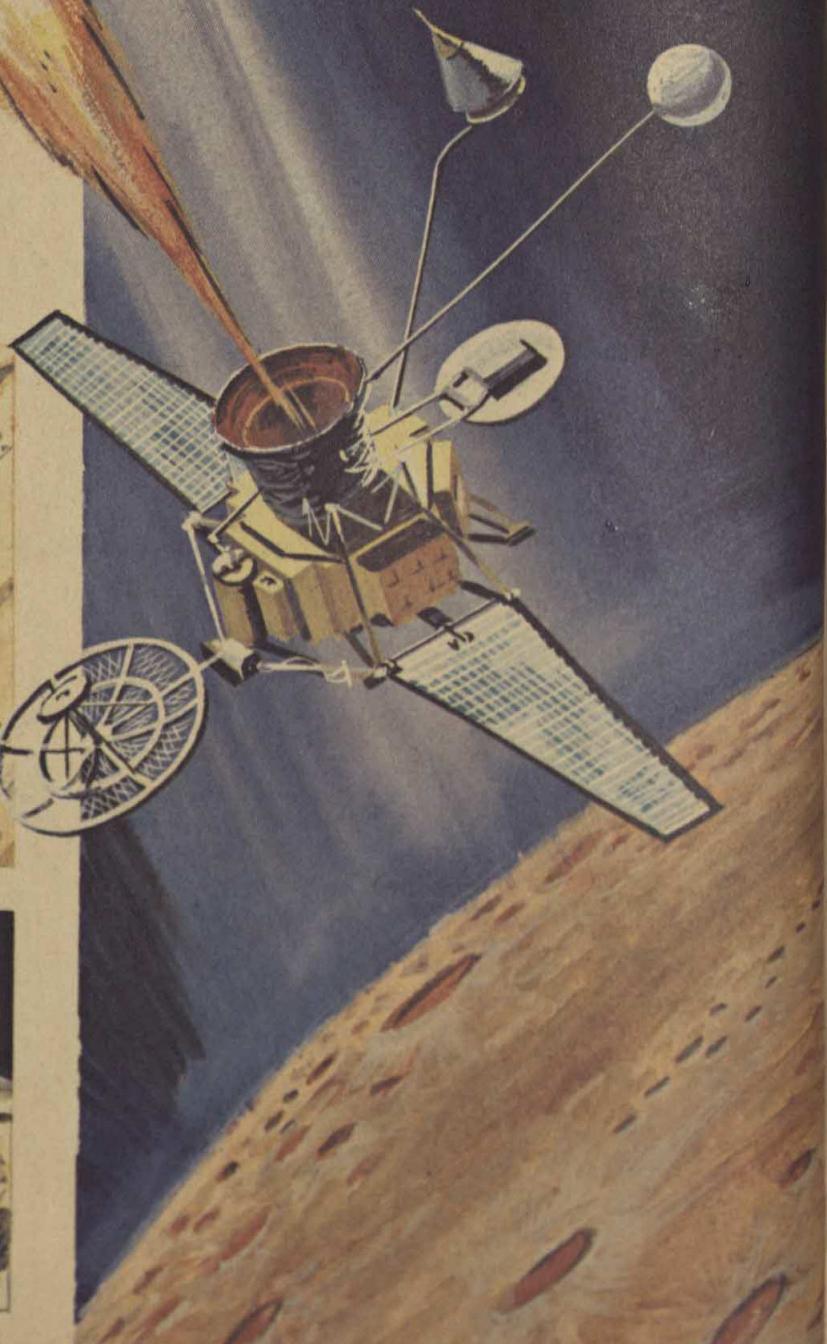
The first unmanned moon probes planned by NASA are known as **Rangers**. According to present plans, there will be several types of

What are the Rangers?

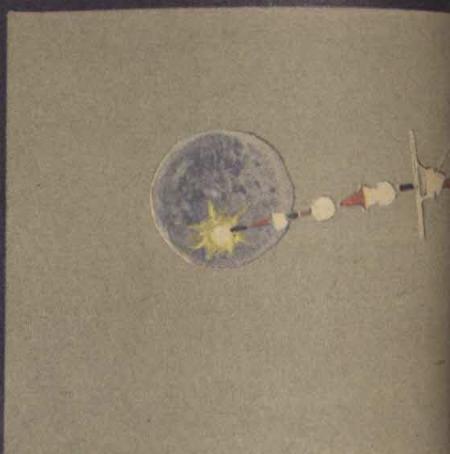


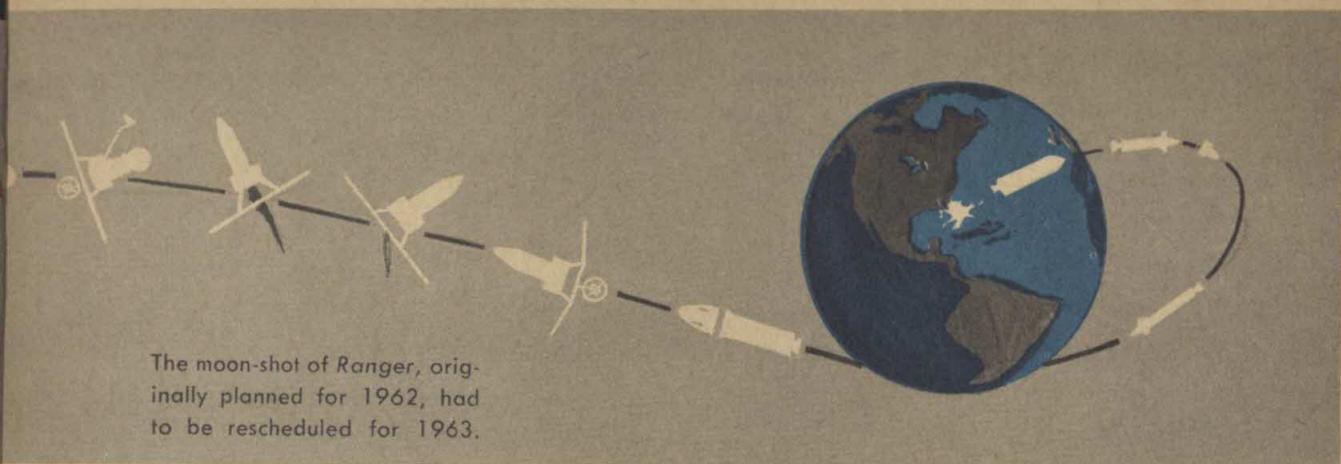
Ranger, the space robot, on its way to the moon to assemble information necessary for the men who will follow later.

The instrument package, already separated from its carrier, is slowed down by a retrorocket to soften the impact of the crash.



The balsa ball, flattened by impact (instrument package exposed in cutaway illustration), comes to rest on the surface of the moon.





The moon-shot of Ranger, originally planned for 1962, had to be rescheduled for 1963.

vehicles in this class. It is very likely that the first one will have made a moon landing before you read these words.

The Ranger will be a small but complicated vehicle. In one section it will carry a television camera, and instruments to detect radiation and other lunar phenomena. It will also carry an instrumented capsule that will actually make a safe moon landing. Ranger will work like this:

After being lifted off its launching pad at Cape Canaveral by a giant Atlas rocket, it will be hurled into an earth orbit by a booster rocket at a speed of 12,600 MPH. Halfway around the world, at a point above South Africa, a second blast from the booster will thrust it into a moon trajectory. At this point its speed will have increased to 24,500 MPH, sufficient to allow it to escape from an earth orbit and head out into empty space. At this point, the booster rocket will drop off, and Ranger will be on its own.

Now the amazingly intricate instruments will begin to unfold. Wing-like panels will spring out from its sides. These panels will capture energy from the sun to be turned into electricity to

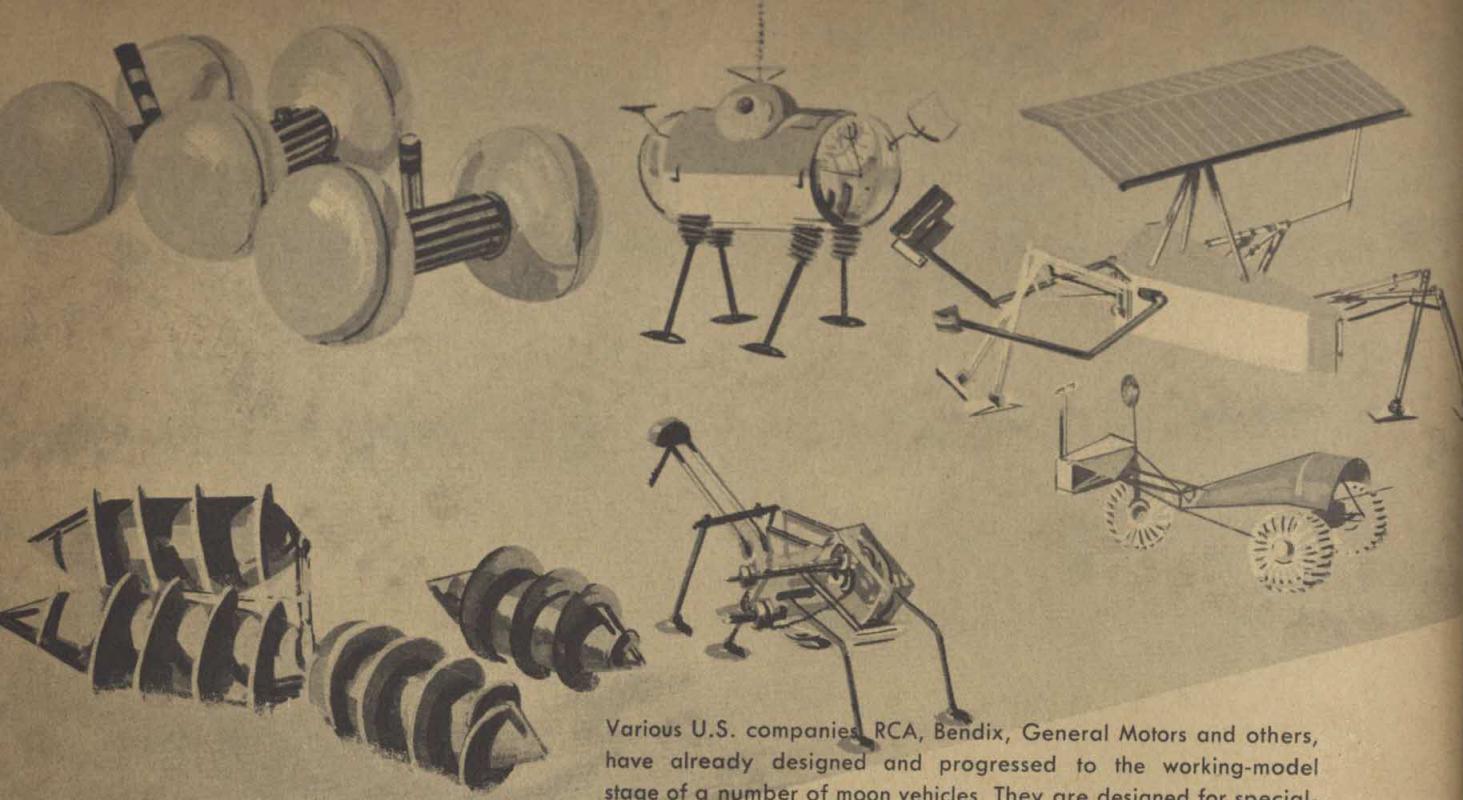
power the Ranger's TV and radio equipment. With the radio working, Ranger will be able to be controlled from ground stations on earth. By the aid of small guidance rockets, the robot will be put on a precise course for a moon landing.

As it approaches the moon's surface, some 66 hours after launching, TV cameras will begin taking the first close-up pictures of the moon. While scientists using earth-bound telescopes cannot see moon-objects less than half-a-mile long, Ranger's camera will be able to record objects no larger than a dining-room table. The pictures will be radioed to earth as rapidly as they are taken, and for the first time scientists will know what the lunar surface looks like in minute detail.

Now the most amazing part of the Ranger will go to work.

What is the balsa ball? Its tip will uncover itself, exposing a blue-and-white ball made of balsa wood, about half again as large as a basketball.

At this point Ranger will be falling into the moon at a speed of about 6,000



Various U.S. companies, RCA, Bendix, General Motors and others, have already designed and progressed to the working-model stage of a number of moon vehicles. They are designed for specialized explorational tasks, after having landed on the moon, and are all equipped with instruments to report the findings back to earth.

MPH; and this speed will be increasing every second due to the pull of the moon's gravity.

When the Ranger is some 70,000 feet above the moon, a retrorocket will blast the balsa ball away from the main body. The retarding force of this little rocket will bring the ball to a momentary stop at a moon-altitude of about 1,000 feet. Then the rocket will jettison itself and the ball will fall free to the surface below.

Meanwhile, the cameras on Ranger will continue to take close-up pictures of the moon and relay them back to earth until Ranger strikes the rocky surface and is completely disintegrated upon impact.

Beginning its fall all over again, from its temporary stop at 1,000 feet, the ball will strike the moon's surface with a

speed of no more than 150 MPH. Since the ball was built to withstand this much of a jar (this has been proved by dropping it from airplanes), it will probably bounce once or twice and then roll to a stop — the first man-made object ever to land safely on the moon!

The ball itself is made of segments of balsa, the lightest and most resilient of all woods, which are fitted together in such a way as to be best able to absorb the jolt of landing. Its peculiar paint pattern is designed to reflect and absorb lunar sunlight, and thus help offset the moon's extremes of heat and cold.

Inside the ball is a seismometer, an earthquake (or in this case a moonquake) recorder, and a radio transmitter. This seismometer can show us many things about the mysteries of the moon.

What will the ball tell us?

For one thing, it can record the number of meteorites that strike the moon, as well as their size, and radio its findings back to earth. This information could mean the difference between life and death for the first moon pioneers. It can also show us whether the lunar surface is firm and hard enough to sustain a manned landing, or whether it is composed of loose dust. Thirdly, it will be able to determine whether or not the moon still has a hot, molten core, like the earth, or is a completely dead and inert body.

The instruments in Ranger's balsa ball are expected to keep operating and sending information back to earth for about a month. Then the power will go dead, but the ball will have done its job.

The second series of Rangers will have a different purpose. These craft

will carry as many as six television cameras as well as instruments for measuring lunar radiation and dust patterns. The cameras will take thousands of pictures of the moon, in far greater detail than those of the first Ranger. When these pictures are shown on your home TV screen — as they probably will be — you will have the breath-taking experience of looking out of the nose of a rocket ship as it crashes on the moon.

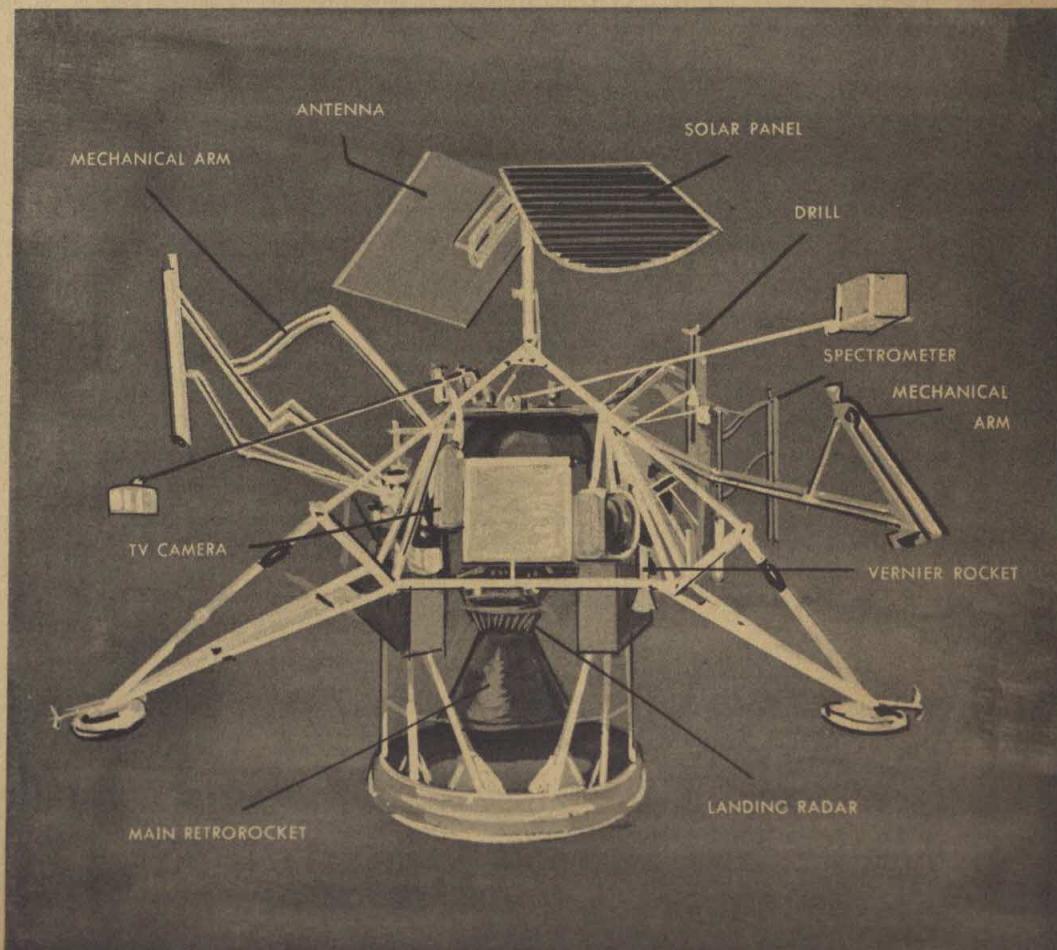
If the balsa balls of the first Rangers have done their work well, no other moon landings will be necessary until the first Surveyor is launched.

The Surveyor-Lander vehicles, the next step after the Rangers, will be launched about two years later. These will be the first robots to make a con-

What is the Surveyor?



The Surveyor space craft with identification of its ingeniously designed components. Surveyor is planned to be landed in 1964.





Cutaway of Saturn-Apollo shows three man crew in command center of spacecraft.

trolled "soft" landing on the moon, just as manned spaceships will do.

Launched in much the same way as the Rangers, the Surveyor will be a far more complicated mechanism. When it comes to within landing distance of the moon, the Surveyor will be lowered gently to the lunar surface on the flaming jets of three powerful retrorockets.

To understand how this is done, remember the pictures you have seen on TV of the launching of rockets from earth. In the beginning they ascend very slowly, sitting almost motionless for a few seconds on the flaming column of jet fire until they suddenly take off. The moon landings will simply reverse this process, allowing the Surveyor to ride the jets *down* instead of *up*.

Once it has landed safely, all of Surveyor's marvelous instruments will go to work at once. Television cameras will scan the moonscape in every direction, taking pictures both in black-and-white and color. For the first time, watchers on earth will be able to determine the true lunar coloration.

Mechanical arms will reach out, pick up specimens of moon material, grind it up, analyze it, and report the findings. Drills will bore into the moon rock and submit it to analysis. Other devices will determine the hardness of the moon's surface, and find out whether it is safe



for a manned landing. Bombardment with X-rays will determine the extent to which the moon retains the hot gases that are thrown out by the sun.

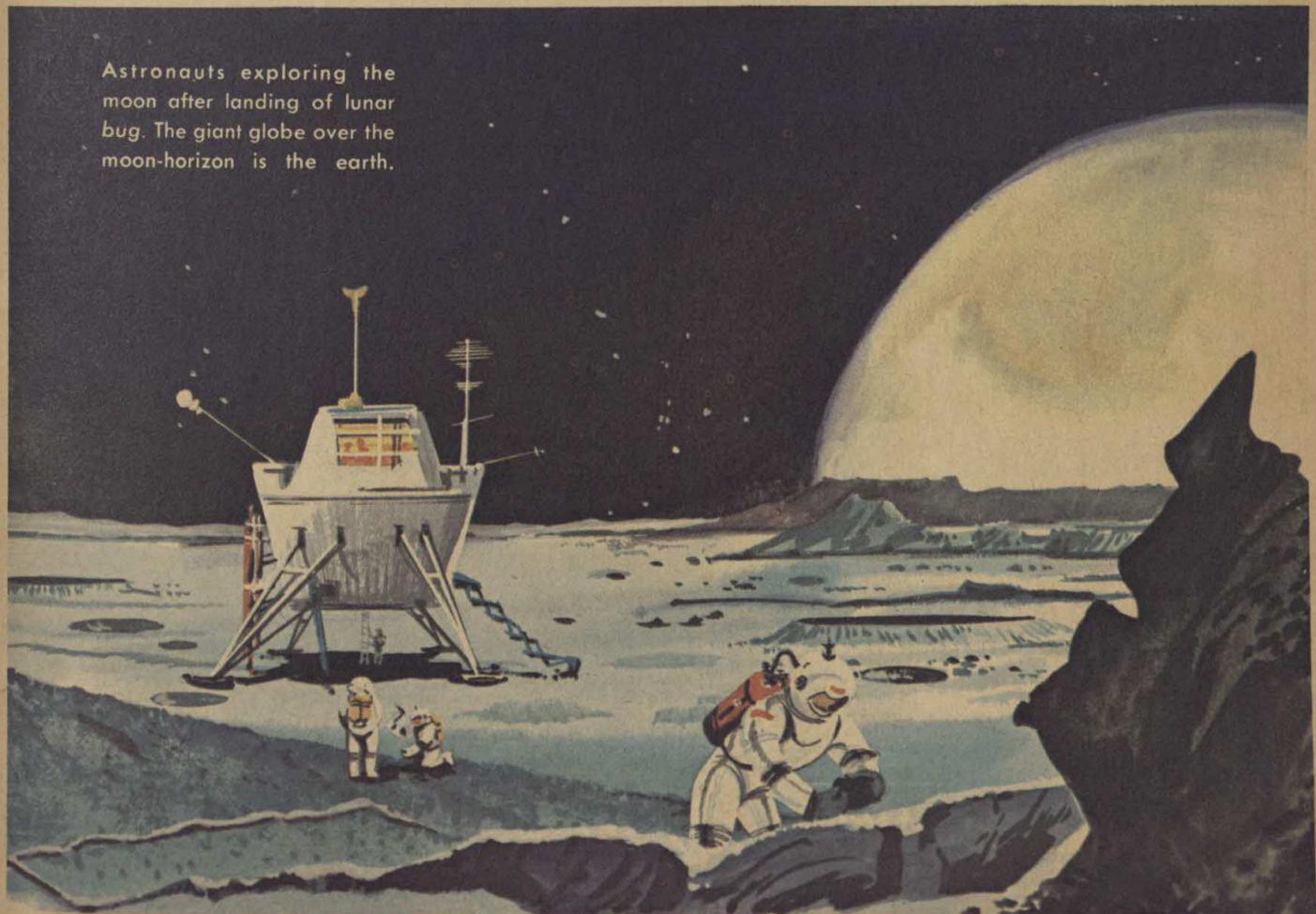
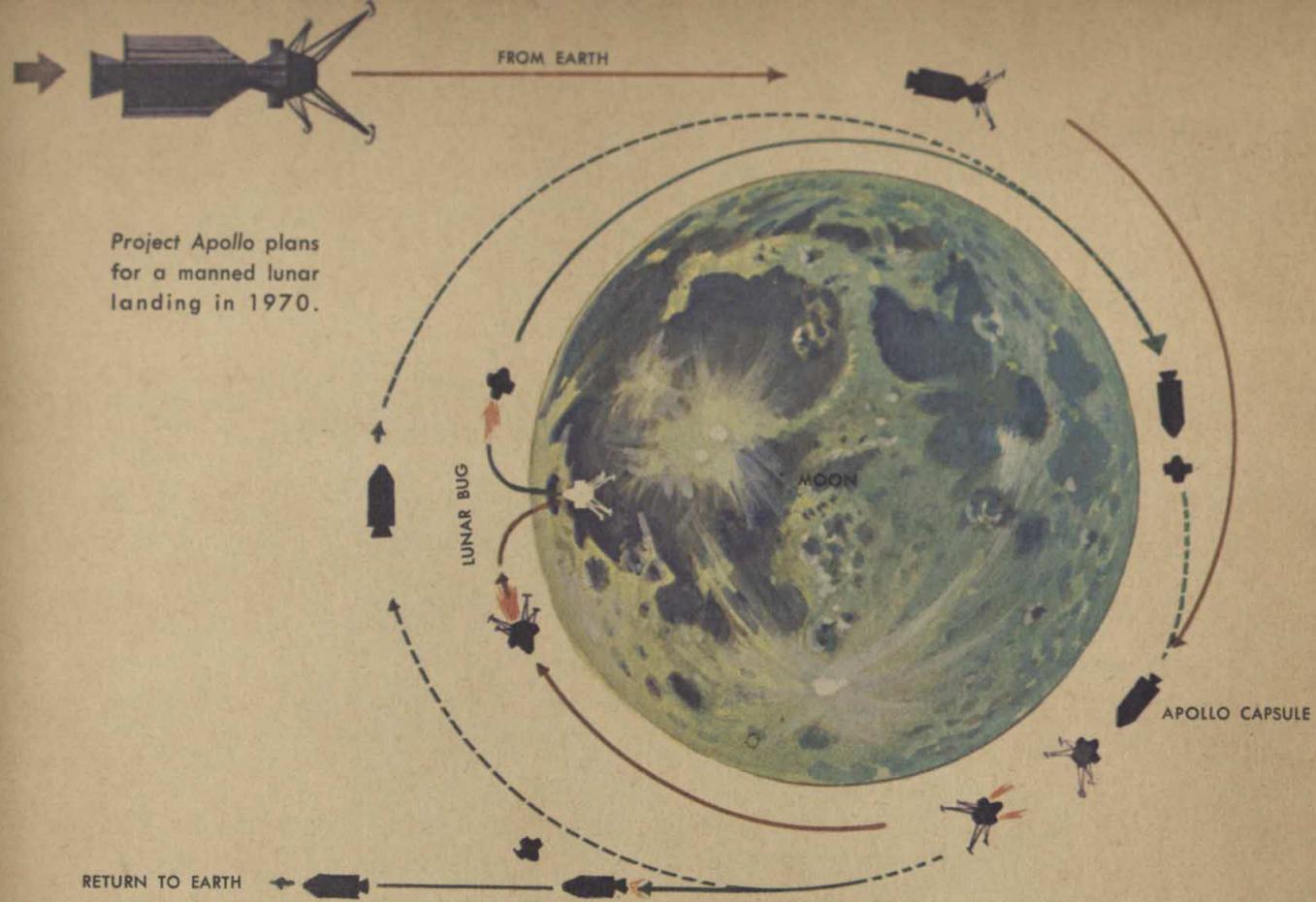
A number of Surveyors will be landed on different parts of the moon so that scientists can decide which particular areas are best suited to later manned landings.

A second series of Surveyors will be known as Surveyor-Orbiters. Instead of landing, they will go into orbits around the moon in such a pattern as to cover, and photograph, the entire surface in a period of about a month. These photographs will be used to make detailed lunar maps and further determine the likeliest spots for later landings by humans.

After the Ranger and Surveyor vehicles

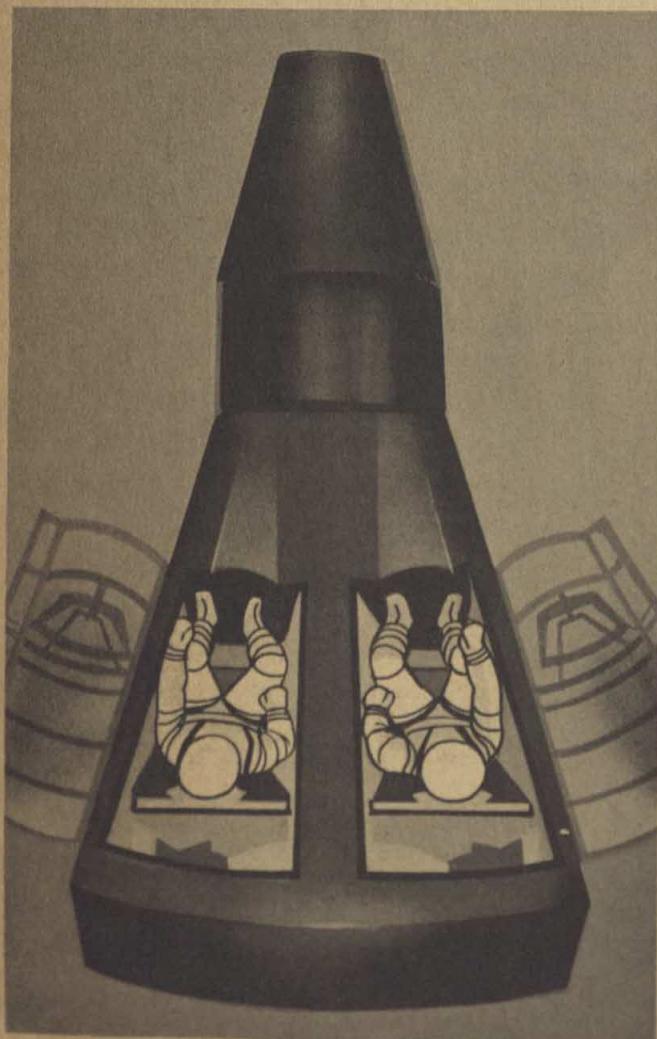
What is
Project Apollo?

have accomplished their missions, the next giant stride in the conquest and exploration of the



moon will be to land a crew of human astronauts. As this book is being written, this project is still in the planning stage. It is believed that the first manned landing will not be possible until about 1969 or 1970. But already our scientists and our space crews are preparing for it. The program for finally landing men on the moon is called Project Apollo.

It is believed that the most feasible method of reaching the moon is by means of an Earth or Moon Orbit Rendezvous. Two spaceships will meet in an orbit around the moon or earth. One of them is a tanker, filled with rocket fuel. The second contains the crew that



Cutaway view of training capsule of Project Gemini.

will make the moon voyage. After replenishing their rocket fuel from the tanker, the second ship then takes off for destination moon.

But before an actual moon trip can be

**What is the
Gemini?**

launched, a great deal of crew training will be required. This training is already well under way. The training ship, a larger version of the one-man Mercury capsules that have already made several earth orbits, is a two-man craft known as Gemini. The chief mission of the Gemini crews will be to perfect the techniques of meeting with tankers while in orbit.

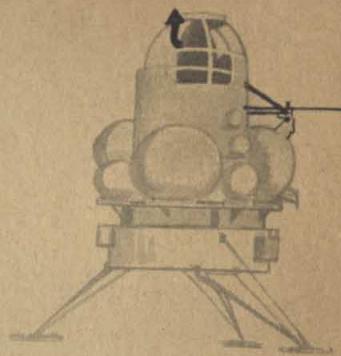
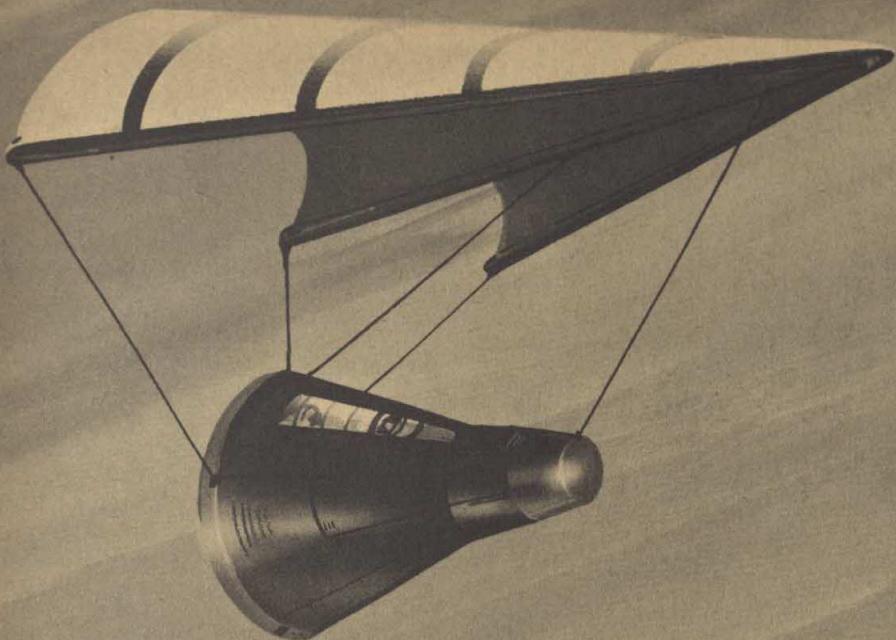
One distinguishing feature of the Gemini capsule is the fact that it will not parachute back to earth and land splashing in the sea as the Mercury capsules have done. Instead it will carry a collapsible "Rogallo wing" in its nose. This odd-looking combination of parachute and glider will inflate upon reentering the earth's atmosphere and allow the astronauts to glide to a landing field.

After several Gemini crews have been

**What is
the "bug"?**

trained, and the rendezvous techniques have been perfected, the astronauts will graduate to the larger Apollo spaceships. Apollo will carry three men, and will contain all the instruments and apparatus needed for an actual moon landing. This will include a small space cruiser officially known as the Lunar Excursion Vehicle, but more familiarly called the "bug."

As the Apollo astronauts orbit the earth in practice flights, they will detach



Sketch of a model of a lunar ferry, or moon bug.

Rogallo wing, an inflatable device that will replace the parachute of Project Mercury, will make it possible to land the Gemini and perhaps Apollo capsules on land instead of in the Ocean.

the "bug" from the mother ship and take short space-rides in it. Then they will return in the "bug" to the Apollo craft before bringing it back to earth by means of the Rogallo wing.

Even with all the exploratory probes,

Why will Apollo first orbit the moon?

and all their previous training, the astronauts will not be prepared to attempt an actual landing on the moon on their first lunar trip in Apollo. Instead, they will probably make one orbit of the moon, at a height of perhaps 100 miles. This orbit will give man his first opportunity to get a good, close-up, look at the lunar surface. The astronauts will observe the moon, compare its moonscape to the maps that will have been made with the help of the Surveyors, and further refine their selection of places on which they will eventually make a landing. They will then return

to earth and land by means of the Rogallo wing.

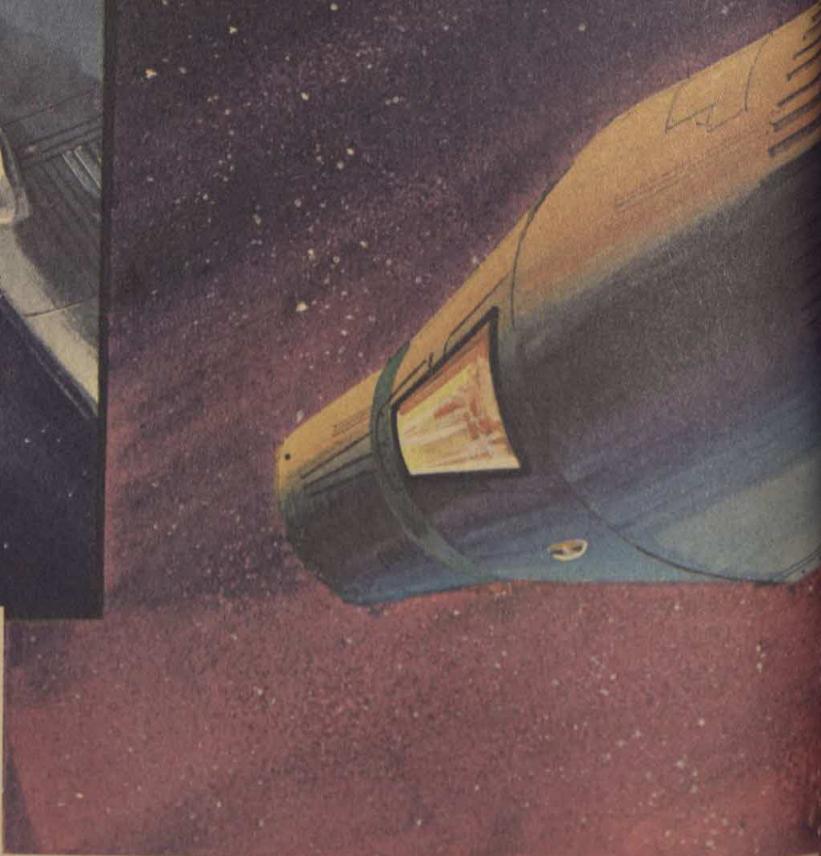
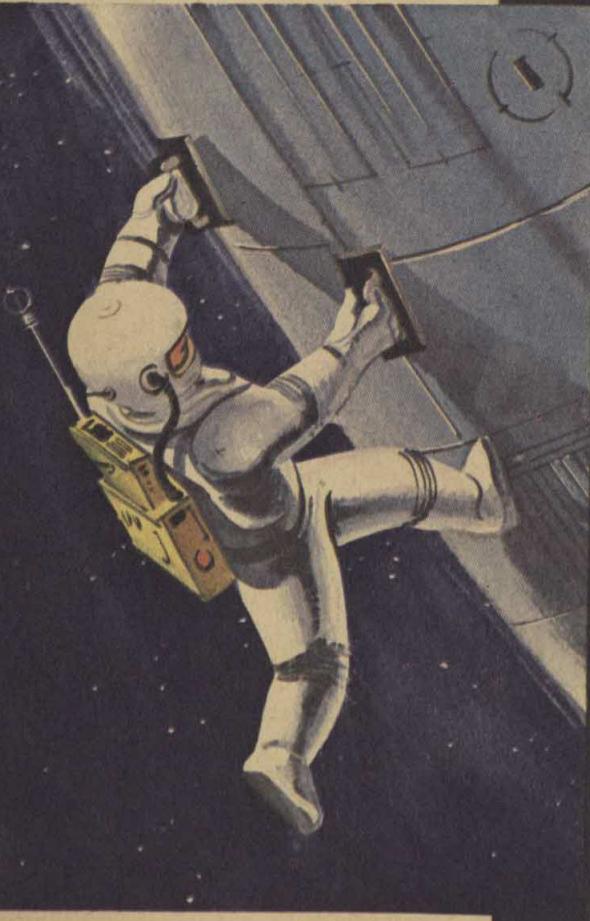
On the second lunar voyage, it is planned that the Apollo will make a number of orbits around the moon, giving its crew an opportunity to take more pictures and spend several hours, or even days, studying the surface below them. They may even bring out the "bug" and fly it around the moon, to get the feel of how it handles when it is within the pull of the moon's gravitational field.

On a flight through space, it will be possible for the astronauts to leave their ship whenever they wish to.

How will men work in space?

Dressed in protective space-suits, they will be able to go outside into empty space to take their "bug" out of its storage space and put it in place for take-off, or to do any of a number of other tasks.

To get the necessary experience for future moon landings, one of the next steps to be carried out closer to the earth, might be the "rendezvous" of two spacecraft, orbiting the earth. Our illustration shows an artist's conception of such a joining of two vehicles, one astronaut "going calling on the other."



Repairs on the outside of the space ship or taking out of the bug will be done while the craft moves at full speed.

As the men are outside tending to these chores, the Apollo will be racing along at the incredible speed of something like 18,000 MPH. The astronauts will also be moving at this same rate. But in relation to the spacecraft, they will seem to be motionless. They will wear boots with magnetic soles to hold

them fast to the metal sides of the ship. They will also be secured by short life-lines to keep them from drifting away into the endless sea of space.

To understand why the astronauts will feel no sensation of speed, think for a moment about the speed at which our own earth is moving. The ground



on which we stand, which seems so quiet and still on a pleasant summer afternoon, is actually spinning around at the furious rate of 1,000 miles an hour. The earth is racing around the sun at a speed of 66,000 miles an hour. And, along with the sun and all the planets, our earth is whizzing around

the outside edge of the Milky Way at nearly half-a-million miles an hour, a speed almost impossible to imagine.

Yet, as we stand on earth, we feel completely motionless. That is the feeling which the astronauts will have as they clamber around the outside of their spaceships.

Then, if all has gone well, the first moon landing will be made. The Apollo, with its three-

How will the first moon landings be made?

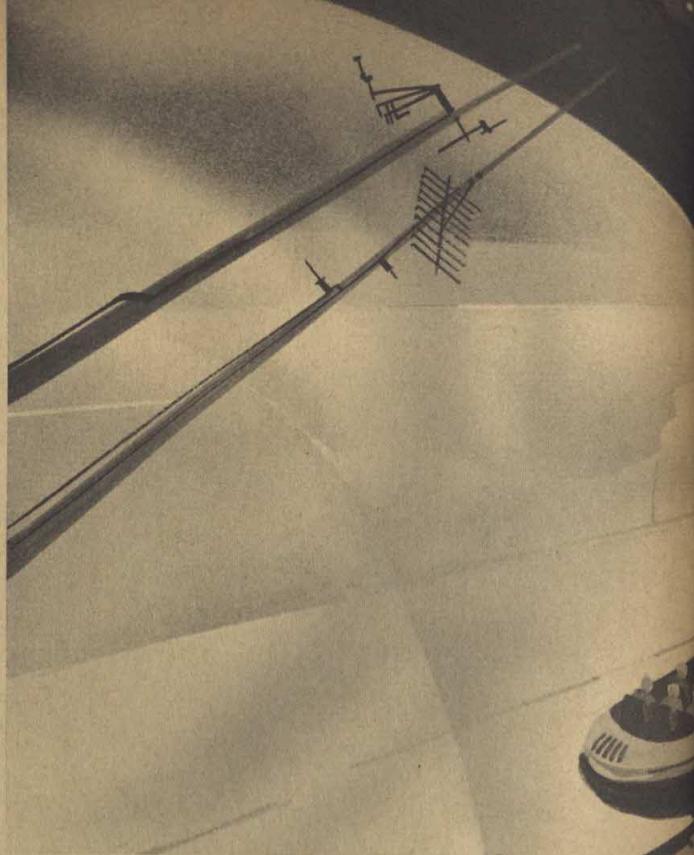
man crew, will go into a 100-mile-high orbit around the moon. Two of the crew will get into the "bug," and put it into a much tighter orbit. At the perigee of the "bug's" orbit, they will only be about ten miles above the moon's surface. If they feel that everything is working perfectly, they will then make a landing much in the same way that the un-manned Surveyor did. They will ease to a touchdown riding four retrorocket jets of flame.

These first men on the moon will not stay long, perhaps only for an hour or two until the mother ship, Apollo, appears overhead. They will be asked to do no scientific tasks. Landing on the moon will be triumph enough. They will jettison their landing gear, fire their take-off rockets, and make rendezvous with the third man who was left in Apollo.

Thanks to the low lunar gravity, and the lack of atmosphere on the moon, taking off will be reasonably easy. They will probably abandon their "bug" which will continue to orbit the moon endlessly, and blast off for home. Back on earth they will find the greatest reception that any humans ever received from their fellow citizens.

This first exploratory landing will be followed by many others. From the first lunar visit of a few hours, successive teams of explorers will stay several days, or even several weeks.

The original team that lands on the



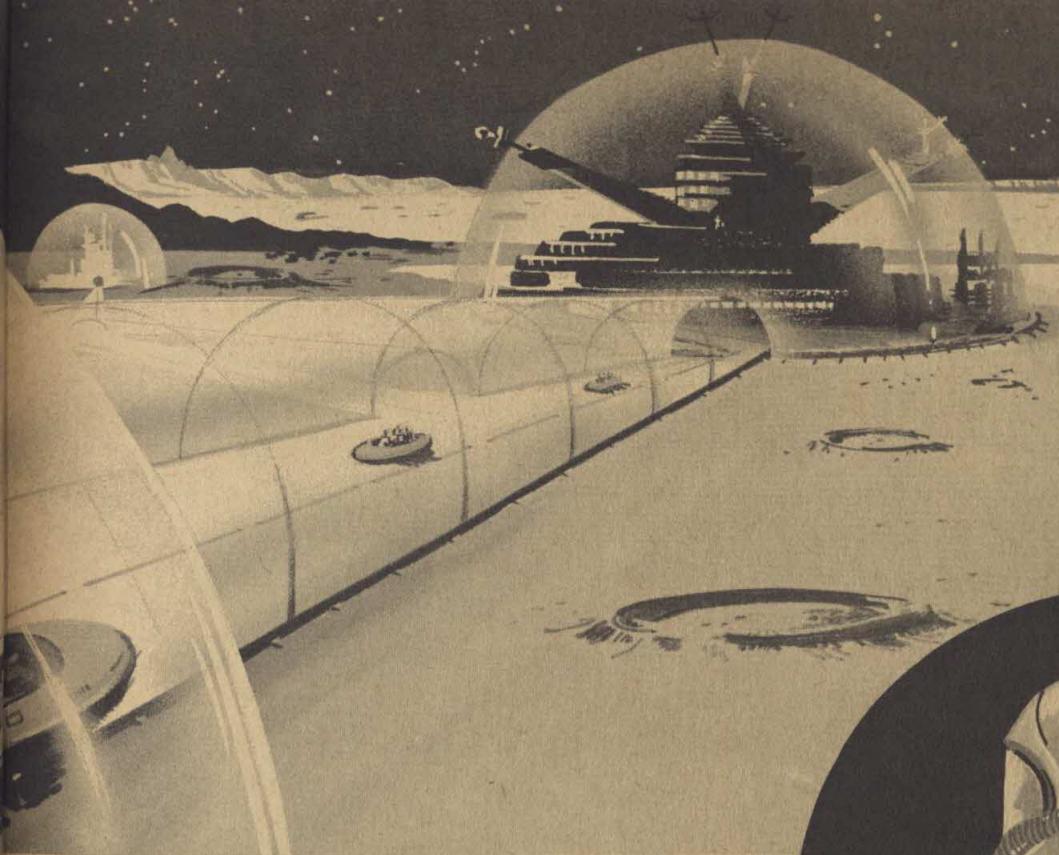
moon may not stray more than a few tentative steps from their vehicle. But subsequent teams will go off on expeditions across the lunar surface. As man gets more accustomed to being on the moon, he will devise ways and means of moving about upon it. Some of these moon-machines are already in the design stages.

The lunar-tractors will employ many different ways to get around the rough and uncertain surface of the moon.

How will the moon explorers get around?

Some of them will walk on spindly legs, in order to step over boulders and other obstructions that may lie in their paths. Others will roll along on ball-like wheels, so as to be able to pass over soft dust areas. Another will be simply a huge plastic ball that could bounce along over almost any kind of terrain.

As the first explorers encounter the



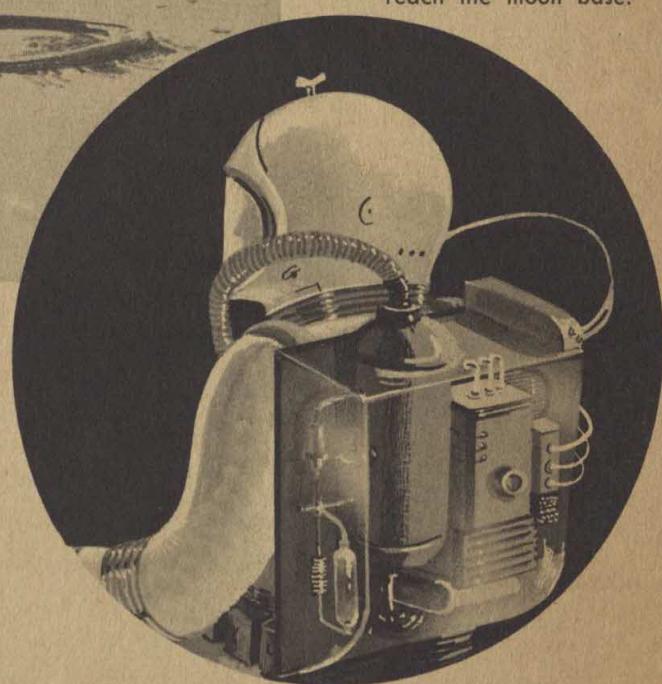
Astrodomes that might later protect lunar bases against bombardment of meteorites, as shown in this artist's conception, are already in preliminary test-stages.

The moon suit has to give enough protection for the spaceman to reach the moon base.

specific problems that moon travel entails, they will be able to determine which kind of vehicle is best suited to their needs. (See ill., p. 38.)

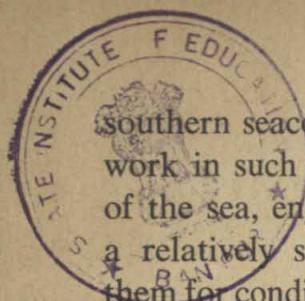
As we have seen, the moon will prove to be a very hostile and inhospitable place to live, even for a short while. Moon explorers, as they walk about the surface, will have to wear spacesuits that protect them from the moon's lack of air, its absence of air pressure, its dangerous solar radiation, and its dangerous extremes of heat and cold.

How will man survive on the moon? The moon-suit will carry food, water, air conditioning equipment, and a two-way radio. The fact that it will weigh 200 pounds, which would make it almost impossible to wear on earth, will be no problem for the moon explorers, since it will only weigh one-sixth of that, or about 33 pounds, on the moon.



To guard against the bombardment of meteorites that are constantly raining down on the moon, the first spacemen will probably dig, or blast, caves into the lunar rocks. Later, they will no doubt erect permanent shelters. These will be pressurized, so that humans can live and breathe in them just as the astronauts will be able to do in their spaceships.

Experimental models for such self-contained astrodomes are already in the preliminary test stages. Built of heavy plastic, the first of these are being tested under water in shallow parts of our



southern seacoast. If men can live and work in such structures at the bottom of the sea, engineers reason, it will be a relatively simple matter to modify them for conditions on the airless moon.

Another great problem will be that of supplies of food, water, and fuel. With today's rockets, it takes more than 100 pounds of rocket fuel to put one pound of payload into a moon trajectory. However, within the next decade, scientists are confident that these problems too will have been solved.

As we have seen, the many riddles of the moon are only just beginning to reveal themselves. You who read this are growing up in the first

You and the Moon

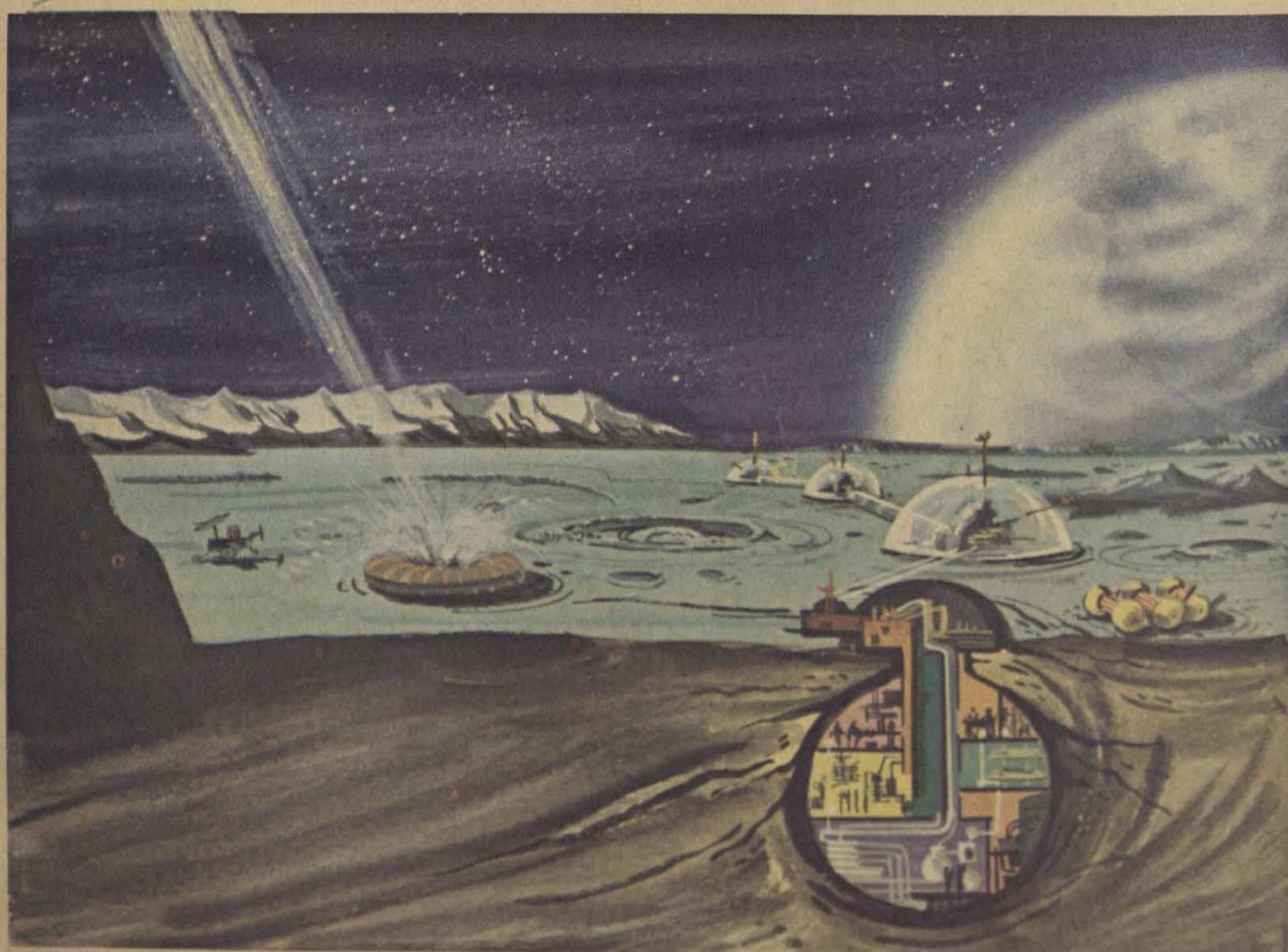
stages of the space age, and it will be well if you learn all that you can about our natural satellite.

Inexpensive telescopes can be readily purchased, or assembled from kits, that will enable you to observe the moon on clear nights in your own backyard. Several types of moon-maps are available for study. A large relief globe of the moon has recently been introduced, and is on sale at most bookstores and toy shops.

Even today, the moon is much closer to us than the New World was to Columbus. You can expect that by the time you are an adult, people will be making regular lunar voyages.

Who knows? Maybe one day you, yourself, may make a trip to the moon!

Lunar landscape, space bug leaving the moon base, and cross-section showing shelters built below the surface.





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